ESTIMATING BUILDING COSTS

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CHARLES F. DINGMAN

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BY

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Architectural Engineer

SECOND EDITION
SEVENTH IMPRESSION

McGRAW-HILL BOOK COMPANY, INC.
NEW YORK AND LONDON
1931

PRINTED IN THE UNITED STATES OF AMERICA

THE MAPLE PRESS COMPANY, YORK, PA.

PREFACE

During the years which have passed since the publication of the first edition of this book, several important changes have taken place in the manner of handling building construction operations and these, in turn, have made it necessary to make corresponding changes in the methods of estimating costs.

The most important changes that have taken place in those branches of building construction covered by this work are these:

Practically complete motorization of all haulage, so that figures based upon the use of horses for hauling and other operations can be applied to only a very small percentage of the total of building projects likely to be considered by any estimator.

Increasing use of power shovels and other types of excavating machinery, and the practical elimination of hand excavation, except for trenches and other minor work.

Use of portable saws, drills, and other small tools to perform operations formerly done entirely by hand.

Use of the "cement-water ratio" as a means of specifying the proportions of the materials in concrete, instead of the old fixed-ratio method.

Due consideration has been given to all of these changes in revising the text and new data and tables have been included to make this work as serviceable under present conditions as the first edition was at its date of issue.

Increasing use of key-driven types of calculating machines, such as the Burroughs Calculator and the Comptometer, in builders' offices has shown the desirability of having as many of the tables as possible arranged so that they may be used by direct multiplication. For that reason practically all of the tables in this new edition are arranged so that they may be used to make an estimate without using the process of division, though there were a few instances where it seemed

that the data would be more usable if the old form were retained.

New chapters, covering Interior Marble, Tile and Terrazzo Work, Foundation Work, and Cement Gun Work have been added. It is believed that, while those branches of the work should generally be sublet by the general contractor, there are a sufficient number of instances when he will want to be able to figure their costs, to warrant the inclusion of the data here.

On the larger buildings, an increasing number of items formerly made of wood, and installed by the general contractor are now being made of metal or other fire-resisting materials and installed by sub-contractors or service men specializing in those items. No attempt has been made to cover those items in this work, since prudence dictates that the general contractor secure sub-bids in practically every instance.

The continued gratifying sale of copies of the first edition confirms the belief that the general style and arrangement of the book are such as to make it a serviceable tool, both for the student of estimating and for the practical estimator who wants a means of reference for such data as he may not have at hand, so the plan of the book has not been altered, except to make the changes noted above and to include an appreciable number of tables of data that were not included in the first edition.

Illustrations have been included where it was thought that they would facilitate the use of the data in the text.

This edition would not be complete without a reiteration of the grateful acknowledgment, made in the first edition, to Mr. Ralph Duane Strecker, formerly Assistant Engineer, Flynt Building Organization, and Mr. George B. Burgess, formerly Assistant Manager, H. P. Cummings Construction Company, for their assistance in checking the data and for helpful criticisms made during the preparation of the text.

Charles F. Dingman

Palmer, Mass.
December, 1930.

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CHAPTER I

INTRODUCTION

The present volume is the result of about 22 years consideration as to the best method of presenting, to the ambitious young men in the building profession, the rudiments of the knowledge required to become competent estimators.

No single book can make a competent estimator of any man, and no claim is made that this book will accomplish that result, but a diligent study of the methods laid down and the principles expounded will develop the necessary habits of thought which, combined with practical experience and keen observation, will enable the student to become such an estimator.

The successful estimator is essentially a visualizer; he must be able to take a set of plans and specifications, with the quantity survey, and mentally see the several parts of the building put together. If he cannot do that, all the data available are not always sufficient to keep him from making an estimate that is far too low or far too high.

It is not intended that this book shall be primarily a "data-book," though it necessarily contains a great deal of estimating data, much of it presented in tabular form. Nor is it intended that this book shall replace or supersede any of the many excellent reference books and hand-books that have been published for estimators' use.

Those books are essentially data-books and are intended for use only by men who already possess a competent knowledge of estimating principles or who, in the capacity of appraisers or adjusters, want to arrive at figures very quickly.

This volume is intended for the less experienced man, to train him to analyze every construction job into its component parts, to apply his cost data, adjusted to existing conditions, to the several necessary operations and thus to calculate a price that will approach the actual cost of doing the work as closely as is humanly possible.

Naturally, in a work of this size, the treatment is not exhaustive, since entire volumes have been published on the subjects of earth and rock excavation alone, and a similar volume has been published on concrete work. Brickwork and carpenter work could well fill equally large volumes.

However, each subject has been treated at sufficient length to enable the reader to get a clear insight into the factors involved, their relative importance, and the methods to be employed in estimating their cost.

There are two general methods employed in preparing an estimate; one method is to summarize all of the costs involved in a unit quantity of the item under consideration, then to multiply the figures thus derived by the number of units. The other method is to calculate the total quantities of materials and labor needed to complete the operation and, multiply by their individual costs, determine the total estimated cost of the operation.

The first method has the advantage of presenting the information in a form that makes it possible readily to adjust the estimate for reductions or increases in quantities, if any are made. It is probably the handiest method for use by an experienced estimator whose training is such that he will be certain to include all the accessory costs in his unit prices.

For the student, the second method seems better and is used throughout the text, but it is well to form the

habit of resolving all totals back to unit prices, as this affords an opportunity for a mental check on your work, a means of comparison with other estimates and a method of following the trend of costs in each department of work.

Such subjects as Plumbing, Heating, Electrical Wiring, Mechanical Equipment of Buildings, and other specialties have not been included at all because it is not considered a safe practice for a builder to attempt to estimate those items himself. Sub-bids should always be secured from specialists in those lines and they will be competent to evaluate properly all specification requirements, as well as current market and labor conditions. No matter how competent a building estimator may be in his own field, it is not reasonable to expect him to have an intimate knowledge of the business of all of the specialists with whom he will have to deal.

It will be noted, in working out many of the examples in the text, that fractional quantities have been increased to full quantities and fractional hours to full hours. The present status of refinement in the methods of handling materials and administering labor on construction work is not such as to warrant too great a refinement in estimating methods and the percentage of error thus introduced is not sufficiently large to affect the results of bidding.

Price lists have not been included in the text because it is deemed essential that the estimator in active practice should always obtain the current prices on all materials directly from his sources of supply and he will thereby eliminate a very important source of error.

For instance, it might be very interesting to an estimator to have a price list of the various sizes of steel sash, together with information as to the manufacturers' methods of pricing.

But prices change and local conditions affect sales policies, while there is seldom an occasion that does not allow time for obtaining prices direct from manufacturers or dealers, so there is no practical advantage in having the price list.

One thing this book attempts to accomplish, that is to induce estimators to pay more attention to the method of obtaining and recording data on the basis of production per man-hour rather than on that of the money cost per unit.

The possible production per man-hour is a reasonably constant quantity but money costs vary with every market change and, unless every condition is properly recorded, money costs reported for one operation may not be of any use in estimating the cost of a similar operation performed under different circumstances.

CHAPTER II

EXCAVATING, GRADING, BRACING, HAULING

SECTION I. EXCAVATION BY HAND

Because of the apparent simplicity of the operation of excavating in most building construction, it is not usual to give as much consideration to estimating the cost as the importance of this item would warrant.

There are so many factors which affect the cost of excavation that it is really one of the most difficult parts of building work to estimate accurately.

Computing the quantity of material to be excavated is a comparatively simple matter, but consideration must be given to all of the following factors:

Care must be taken to include the dimension from outside to outside of the spread of footings and also from the top of the grade to the underside of the cellar floor construction. Footing trenches, pier-holes and other excavations extending below the general cellar excavation should be figured separately, under proper headings, and individual prices computed for each class of excavation.

When the nature of the soil is such that the banks will not retain their vertical position without support, proper allowance must be made for bracing. With shallow excavations, or where building lines or other constructions do not interfere, it will usually be found cheaper to slope the banks than to brace them. A discussion of the cost of bracing will be given further on.

If the banks are to be sloped it will be necessary to figure the cost of excavating a prism of earth all around the excavation, the dimensions of this prism being determined by the depth of the excavation and the angle of

repose of the material to be excavated. The volume of this prism will also have to be added to the quantity of backfilling.

The angle of repose, or the slope which the material will maintain without further sliding, is approximately as follows:

TABLE 1.—ANGLES OF REPOSE[1]

Material	Angle dry	Degrees from horizontal	
		Moist	Wet
Sand	20–35	30–45	20–40
Earth	20–45	25–45	25–30
Gravel	30–48		
Gravel, sand and clay	20–37		

[1] Re-tabulated from information given in the "Handbook of Building Construction," by Hool and Johnson. McGraw-Hill Book Company, Inc., New York.

Variations in Soils.—These figures are, of course, subject to as wide a variation as there are variations in the soil formation at different places. Determination of the angle for any particular kind of earth can only be made by observation, and the estimator should make it his business to be sufficiently conversant with the soils in his vicinity to approximate the angle of repose in any instance, or he should get that information from some one who is familiar with local conditions.

In fairly firm soils, footing and pier excavations can be figured as the net width of the bottom course (provided the architect or engineer will permit the work to be executed that way), without allowance for forms, but sufficient space must be allowed for footing forms in unstable soils and for wall or pier forms in all cases where they will be used. This allowance is usually taken as one foot from the face of the wall.

Where the area to be excavated is comparatively small and the depth of the cut is not over nine or ten feet, the shovelling will usually be done entirely by hand and the figures in Table 2 represent the amount of earth that can be loosened and shovelled out per man-hour.

In very shallow footing trenches the production will vary but slightly from the figures in the first two columns but for deeper trenches and for deep and narrow pier pits the production will be reduced, as indicated in the third and fourth columns.

Table 2 is to be used in cases where the material is to be thrown into carts or out onto banks not over 6 feet high.

For greater heights than 6 feet it will be necessary to throw the spoil out in two or more "lifts" or to handle it mechanically. Of course, where it is practicable to run the carts down into the excavation, the material can always be shovelled directly from the floor of the cut into the carts as usual.

Where spoil is handled manually by one or more "lifts" it is necessary to figure the cost of a scaffold or platform, from which the second or subsequent "lifts" are to be made and the labor of shovelling will be calculated for each lift on the basis of the figures in Table 3.

The cost of erecting scaffolds will be taken up in Chapter III, in connection with Brickwork.

TABLE 2.—HAND EXCAVATION
(Man-hours per 100 cubic yards)

	General work		Trenches	Pier pits
	Dry	Wet		
Sand or loam	89	124	182	196
Ordinary medium soil	124	250	322	344
Heavy soil or clay	222	333	416	435
Hard-pan	250	400	500	526

TABLE 3.—SHOVELLING EXCAVATED MATERIAL

(Man-hours per 100 cubic yards, material previously loosened by plowing, or other means)

	Hours
Ordinary medium soil....	82
Sand or loam............	80
Heavy soil or clay.......	105
Hard-pan...............	118

SECTION II. PLOWING AND SCRAPING

Where the area to be excavated is sufficiently large to permit the plow to be operated efficiently, it will often be found economical to use a plow to break up the soil and prepare it for the shovellers, thus practically obviating the need for picking for as much of the depth as is plowed.

The figures in Table 3 are to be used for estimating the cost of shovelling out after plowing.

When scrapers are to be used, except for such loose material as sand or gravel, it is almost always necessary to loosen up the soil before scraping.

TABLE 4.—PLOWING

(Hours work required to loosen 100 cubic yards)

	Two-horse plow	Four-horse plow	Tractor plow
Top soil..........................	2.5	....	1.18
Ordinary medium soil...........	2.86	....	1.34
Heavy soil.......................	3.00	....	1.45
Soft clay.........................	5.00	....	2.22
Stiff clay.........................	....	5.00	2.86

Comparatively shallow excavations in sand, gravel or loose soil can often be handled very economically by means of scrapers, particularly if the excavated material may be disposed of within a very short distance.

The maximum distance for economical use of ordinary drag-scrapers is 200 feet, and for wheel-scrapers it is 500 feet.

Since the drag-scraper will carry 4 cubic feet of material (the nominal capacity is 5 cubic feet) and the team will average a speed of 2 miles per hour or 176 feet per minute, it follows that the time cost of moving a cubic yard of earth a distance of 200 feet, allowing 25 feet at each end for turning and ½ minute per trip for loading and dumping the scraper, will be as follows:

$$27 \div 4 = 6.75 \text{ trips per cubic yard}$$
$$225 \div 176 = 1.28 \text{ minutes per trip each way,}$$

or 2.56 minutes per round trip, plus ½ minute for loading and dumping, equals a total of 3.06 minutes per trip; therefore, 6.75 trips at 3.06 minutes equals 20.65 minutes of team time per cubic yard. Allowing for unforeseen delays this should be figured as 23 minutes per cubic yard.

In addition to the time of the teams and drivers, it is necessary to have at least one man to load the scrapers. He can handle about 150 scrapers per hour, which means that a sufficient number of scrapers should be employed to have them load on 24 seconds headway. Where a less number of scrapers is in use the helper's time will be distributed over their work at a proportionately greater cost per cubic yard.

Wheel-scraper work may be figured by the same method, in each case the actual capacity should be taken as 80 per cent of the rated capacity, and the cost of a "snatch" team should be included when the rated capacity of the scraper exceeds 14 cubic feet or where the incline is steep.

When the earth is loosened by the plow to prepare for scrapers, the cost of plowing will, of course, be the same as when preparing for hand shovelling.

TABLE 5.—SCRAPER EXCAVATION
(Hours work required to handle 100 cubic yards)

	Horse-drawn		Tractor-drawn drag-scraper
	Drag-scraper	Wheel-scraper	
Loose material:			
50-foot haul	12.4	8.7	
100-foot haul	18.9	13.2	4.3
150-foot haul	25.6	18.4	5.6
200-foot haul	39.6	27.0	8.5
Firm material:			
50-foot haul	13.4	9.8	
100-foot haul	20.4	14.4	4.5
150-foot haul	28.8	19.6	6.1
200-foot haul	41.6	29.4	9.1

SECTION III. MOVING EARTH. HAULING

The earth shovelled out will, of course, have to be moved away by barrows, carts, motor trucks, cable-way or other means. Since the first three are the most usual for building construction, they are the only ones that will be considered in detail here.

The general building contractor should, as a rule, seek either unit or lump-sum sub-bids from excavating contractors when the work to be done is unusually complicated, but the matter contained in this chapter will be ample to enable him to estimate on any ordinary piece of work.

Wheelbarrows are not usually economical except for moving over very short distances, and the amount which one man can transport per 100 feet per hour is as follows:

TABLE 6.—WHEELING

(Cubic yards of earth moved 100 linear feet by one man per hour)

	Dry	Wet
Sand or loam	1.8	1.6
Ordinary medium soil	1.7	1.4
Heavy soil or clay	1.5	1.2
Hard-pan	1.4	1.1

TABLE 6*A*.—WHEELING IN BARROWS

(Man hours required to move 100 cubic yards)

Distance in feet	25	50	75	100
Sand or loam dry	14	28	42	56
Sand or loam, wet	16	32	48	64
Medium soil, dry	15	30	45	60
Medium soil, wet	18	36	54	72
Heavy soil or clay, dry	17	34	51	68
Heavy soil or clay, wet	21	42	63	84
Hard pan, dry	18	36	54	72
Hard pan, wet	23	46	69	92

A two-horse cart, having a capacity of 1.50 cubic yards of loose material, which equals about 1.20 cubic yards measured before excavating, can travel at the rate of about 2 miles per hour when loaded and 3 miles per hour returning; 5 minutes must be allowed on each trip for dumping and turning and 10 minutes for loading. This quantity is for fairly good roads; if the roads to be traversed are poor, the quantity hauled will be reduced in proportion.

Where the grade of the ramp out of the excavation is very steep it will be necessary to keep a helper or "snatch" team of horses, with driver, on hand to assist the other

teams. The cost of this additional team and driver will be distributed over the production of the other teams and will become less per cubic yard as the production of the other teams increases.

In most instances it will be necessary to keep a man at the dump to spread the excavated material as it arrives. He can usually spread about 10 cubic yards per hour. If material is delivered at a more rapid rate than that, an additional man will be required. In other instances no provision will need to be made for spreading at the dump, but this should always be investigated and considered when making an estimate.

TABLE 7.—HAULING

(Hours required to move 100 tons over good earth roads—allowance made for loading and dumping)

	One-horse cart	Two-horse wagon	One-ton truck	Two-ton truck	Five-ton truck
¼ mile haul	74.0	33.6	16.8	8.3	4.0
½ mile haul	107.0	50.0	25.0	13.0	5.5
1 mile haul	164.0	80.0	35.2	17.4	7.0
1½ mile haul	244.0	110.0	46.4	22.6	9.0
2 mile haul	294.0	148.5	57.8	28.2	11.0

For other kinds of roads, multiply the times given above by these factors:

	Horse-drawn vehicle	Motor truck
Plowed ground	3.0	3.2
Poor dirt road	1.4	1.2
Hard gravel road	0.85	0.75
Good macadam road	0.80	0.70
Best concrete road	0.80	0.65

For other materials or commodities, multiply the time determined for 100 tons by these factors:

100 cubic yards earth, sand or gravel	1.35
100 cubic yards ¾-inch crushed trap rock	1.30
100 cubic yards 1½-inch crushed trap rock	1.28
100 cubic yards 1½-inch crushed limestone	1.18
100 cubic yards ¾-inch crushed granite	1.25
100 cubic yards 1½-inch crushed granite	1.20
100 cubic yards crushed slag	1.00
100 barrels Portland cement	0.19
100 barrels lump lime (large)	0.15
100 barrels lump lime (small)	0.10
100 thousand common bricks (dumped)	2.25
100 thousand common bricks (piled)	2.35
100 thousand face bricks (piled)	2.93
100 thousand FBM dressed hard pine timber	1.76
100 thousand FBM soft pine timber	1.10
100 thousand FBM douglas fir timber	1.67
100 thousand FBM spruce or hemlock	0.93
100 thousand FBM oak timber	1.58
100 thousand FBM maple flooring	1.78
100 thousand FBM hard pine flooring	1.40
100 thousand FBM hard pine sheathing	1.36

Time for quantities other than 100 units can be determined by multiplying by the number of units and pointing off the proper number of decimal places.

Time for materials not listed here can be determined by using the tables of weights given under the several headings.

SECTION IV. BACKFILLING

In practically every building operation it will be necessary to back-fill and tamp the spaces between the banks and the construction. When the earth to be back-filled is available alongside the trench, the cost may be figured on the following basis:

TABLE 8.—BACK-FILLING BY HAND

(Man-hours required to shovel in 100 cubic yards)

Sand or loam	40
Ordinary medium soil	50
Heavy soil or clay	66

When it is necessary to wheel the earth from a pile away from the trench, the cost of such wheeling must be figured as previously explained.

SECTION V. POWER EXCAVATION

It is hardly within the scope of a book of this size to attempt even to cover adequately such a broad subject as Power Excavation. It occupies a large portion of the contents of such books as Gillette's "Handbook of Construction Cost," Gillette Publishing Co., Chicago, and with its kindred subject, Rock Excavation, furnishes sufficient material for two other rather large books by the same author.

For very large and fairly deep excavations a power shovel should show an appreciable saving over any other method of excavation. However, most building contractors do not make a practice of owning their own power shovels, but will sub-let such work to an excavating contractor at a lump sum or unit price.

Capacities of different shovels of the same nominal rating will vary appreciably and the estimator should be familiar with the performance of the machine which he proposes for any particular work.

But, since a great portion of the time of the shovel will be used in moving, it is not wise to figure upon an actual production of more than one-half of the amounts just given.

The cost of disposing of the material will be the same as for hand excavation, except that the loading time will be greatly decreased, one minute being about the maximum if the work is arranged properly.

If constantly employed in digging, the following production could be obtained from the various sized shovels:

TABLE 9.—POWER SHOVEL WORK

(In ordinary medium soil)

Size of Shovel, Cubic Yards	Capacity per Minute, Cubic Yards
¾	2.25
1¼	3.75
1½	4.50
1¾	5.25
2	6.00

(Hours work required to handle 100 cubic yards)

Cubic Yard Shovel	Hours
¾	0.75
1¼	0.45
1½	0.38
1¾	0.32
2	0.28
Truck-mounted crane	2.9 to 3.8

SECTION VI. PREPARING AN ESTIMATE

No allowance has been made for foreman, superintendent, timekeeper, etc., in any of the figures thus far. The general building contractor will find it most practicable to estimate the total time required for the entire building and to calculate the cost of salaries for superintendent and timekeeper on that basis.

The time of foreman must, however, be included in the cost of excavating and, as one foreman can usually handle any ordinary sized operation, the procedure for calculating the unit cost of excavating for a typical building will be as follows:

It is assumed that the soil is dry clay, that the banks will stand without bracing, that shoveling will be done by hand and the material disposed of in a dump a mile away over fairly good roads.

Cost per 100 Cubic Yards

Plowing (Table 4) 5 hours @ 2.05	$ 10.25
Shovelling (Table 3) 105 hours @ 55	57.75
Hauling (Table 7) 80 × 1.35 = 108 hours @ 1.50	162.00
Trimming dump, 10 hours @ 55 cents	5.50
Total for 100 cubic yards	$235.50

Rates used: cart or plow with driver $1.50 per hour
Laborers 0.55 per hour

Cost per cubic yard, as above	$ 2.355
Foreman, receiving 75 cents per hour straight time, will average 90 cents per hour actual time, allowing for rainy days, etc. Assuming the entire gang to be proportioned to the capacity of the plow, 20 cubic yards will be loosened per hour; therefore, the cost for foreman will be	0.045
Waterboy @ 25 cents per hour	0.0125
Contingencies 5 per cent	0.126
Compensation insurance 5 per cent on payroll	0.032
3 per cent on team hire	0.07
Total cost per cubic yard	$ 2.6405

to which must be added general supervision, office overhead and profit, unless these items are included in other divisions of the estimate, so that $3.00 to $3.15 per cubic yard would be a fair price of this particular job.

Now, if this job can be handled by a suitable power shovel, the plowing may be eliminated, and with motor haulage, the cost would be:

Digging, ¾ cubic yard shovel, 0.75 hours @ $7.00	$ 5.25
Hauling, 5-ton truck. 7 × 1.35 = 9.45 hours @ $3.50	33.08
Trimming dump	5.50
Foreman on basis of 50 cubic yards per hour	1.80
Waterboy on same basis	0.50
Total	$ 46.13
Contingencies 5 per cent	2.31
Compensation insurance 5 per cent on payroll	0.39
3 per cent on machine hire	1.15
Cost per 100 cubic yards	$ 49.98

which, with the addition of the general supervision, overhead and profit, would justify a price of about 60 cents per cubic yard for the job.

SECTION VII. BRACING

Bracing used in ordinary building excavation may consist of wood, concrete or steel sheet-piling. Concrete and steel sheet-piling may be considered as specialties usually handled by organizations specializing in that class of work.

Thickness of plank to be used for sheet-piling and the spacing of waling strips and braces will, of course, have to be determined by calculating the load which the piling must retain. This is calculated after ascertaining the weight per cubic foot of the material and its angle of repose.

However, for excavations not over 10 feet deep, 2-inch plank with 6 by 6 wales not over 5 feet apart, the wales being supported by bracing not over 7 feet apart, will usually suffice.

For excavations 10 to 15 feet deep it is best to figure upon 3-inch plank with 8 by 8 wales, not over 3 feet apart near the bottom, and for 15 to 20 feet deep 4-inch plank should be used.

Wood sheet-piling will seldom be found economical for greater depths than 20 feet.

Where union rules or other restrictions do not prevent it, the entire work of sheet-piling can be done by handy laborers, provided they are directed by an experienced man. Where union rules require it, it will be necessary to allow for having certain parts of the work done by carpenters.

Production can be figured upon the following basis:

TABLE 10.—SHEET PILING

	Square Feet per Man per Hour
Setting braces and driving piles:	
For first 10 feet of depth	10
From 10 to 15 feet deep	9
From 15 to 20 feet deep	7
Pulling piles and removing braces:	
For first 10 feet of depth	40
From 10 to 15 feet deep	35
From 15 to 20 feet deep	20

TABLE 10.—SHEET PILING.—(*Continued*)
(Man hours required per 100 square feet)

Depth	Setting braces and driving piles	Pulling piles and removing braces
First 10 feet............	10.0	2.5
From 10 to 15 feet......	11.2	2.9
From 15 to 20 feet......	14.3	5.0
From 20 to 25 feet......	17.0	7.5
From 25 to 30 feet......	20.0	10.5

Of course, the men will work in a gang of two or four, but the cost is to be figured upon the basis of the production per man.

The amount of material required for sheet-piling will be determined by the number of times the piling can be used over again on the same job. On most moderate sized jobs it will be advisable to provide enough plank and bracing to enclose the entire excavation at once.

Example.—To find the cost of sheet-piling for an excavation 60 feet wide, 100 feet long and 10 feet deep. The plank will need to be at least 2 feet longer than the depth of the footing, that is, 12 feet long.

Distance around excavation 320 linear feet

320 linear feet by 12-foot plank by 2 inches thick..............................	7,680 FBM, plank
Wales—3 lines 6 by 6's, 320 feet........	2,880
Braces—6 by 6's, 45 each 8 feet, 10 feet, 12 feet............................	4,050
Stakes—8 by 8, 45 each 6 feet..........	1,485
	8,415 FBM, bracing

The area to be piled is
320 by 10 = 3,200 square feet
3,200 ÷ 10 = 320 hours driving, etc.
3,200 ÷ 40 = 80 hours pulling

Fractional hours are here considered as full hours

7,680 FBM plank at $36 per thousand..............	$276.48
8,415 FBM bracing at $44 per thousand............	370.26
	$646.74
Deduct 60 per cent for re-use value of lumber.......	387.06
	$259.68
Spikes (estimated at 20 pounds per 1,000 FBM bracing), 168 pounds @ 0.05........................	$ 8.40
Labor driving, 320 hours, @ 0.45..................	144.00
Labor pulling, 80 hours, @ 0.45....................	36.00
Contingencies, allow 5 per cent of labor cost.........	9.00
Insurance, allow 5 per cent labor cost...............	9.00
Net cost, exclusive of supervision, overhead and profit	$466.08

Caution.—All labor rates and material prices used in this text are arbitrarily assumed. The estimator should be careful to get the actual rates and prices that will be in effect for every job for which he makes an estimate.

Whenever possible, the necessary sheet-piling and bracing should actually be designed by a competent engineer, then the amount of material to be purchased and handled can be figured more accurately.

Note also that the figures are on square edged plank, which is the most practicable. If matched plank should be specified, 15 per cent must be added to the quantity of plank, and 10 per cent must be deducted from the amount driven or pulled per hour.

Whenever an estimate is made on the cost of excavating, a visit should be made to the place where the work is to be done, the following information obtained, and proper allowances made in the figures:

Nature of soil.
Disposal of top-soil.
Disposal of other excavated material.
Location of dump.
Necessity for spreading at dump.
Local rate for labor.
Local price for teams or trucks, etc.

Cost of any permits required.
Necessity for protecting sidewalk.
Necessity for protecting pavements.
Cost of watchman, if needed.
Cost of maintaining lights, if needed.
Cost of materials, if any are needed.

It is necessary also to include in all estimates a proper amount for general supervision, traveling expenses, home-office expense and profit. These items will be referred to again in succeeding chapters, but attention is called to them here so that they will not be lost sight of.

CHAPTER III

BRICKWORK

SECTION I. MATERIALS

While the Common Brick Manufacturers' Association has adopted a standard size, 8 inches long by $3\frac{3}{4}$ inches wide by $2\frac{1}{4}$ inches high, to be used for all common building bricks and for face bricks, it will probably be many years before the bricks actually used will approach uniformity in size.

Bricks sold in different parts of the country vary materially in size, and in New England alone we find them ranging in cubical contents from 60 cubic inches to 76 cubic inches, or a range of over 25 per cent.

As long as these differences in size endure, it is evident that no arbitrarily assumed figure, such as 21 bricks or $22\frac{1}{2}$ bricks to the cubic foot of wall, can be correct except by some lucky chance that the bricks delivered happen to average either 68 or 64 cubic inches in size and that they are to be laid with $\frac{1}{4}$-inch joints.

Inaccurate Methods.—Such a method, when used in estimating the cost of large quantities of brickwork, is too inaccurate for closely competitive bidding. On the other hand, when securing quotations on bricks, it is no trouble to ascertain the average cubical contents of the bricks and to adjust the estimate accordingly.

Table 11 was prepared for the purpose of determining the number of bricks required and also for determining which of two or more competing makes of bricks would prove cheaper to use at the prices which might be quoted.

Tables 12 and 13 are to be used in conjunction in order to determine the total number of bricks and quantity of mortar needed to complete a given piece of brickwork.

TABLE 11.—NUMBER OF BRICKS REQUIRED TO LAY ONE CUBIC FOOT OF WALL

Average volume of one brick in cubic inches	¼-inch joint	5/16-inch joint	⅜-inch joint	½-inch joint
60	23.7	22.4	21.1	18.6
61	23.5	22.1	20.8	18.4
62	23.3	21.9	20.4	18.2
63	23.0	21.7	20.0	18.0
64	22.4	21.3	19.9	17.8
65	22.2	21.1	19.8	17.6
66	21.9	20.8	19.6	17.4
67	21.6	20.6	19.3	17.2
68	21.3	20.3	19.0	17.0
69	20.9	20.0	18.8	16.8
70	20.6	19.7	18.6	16.6
71	20.5	19.5	18.5	16.4
72	20.3	19.2	18.2	16.2
73	20.0	18.9	17.9	16.0
74	19.8	18.7	17.7	15.8
75	19.5	18.4	17.5	15.6
76	19.1	18.2	17.3	15.4

TABLE 12.—VOLUME OF MORTAR IN CUBIC YARDS, REQUIRED TO LAY 1,000 BRICKS

(12-inch wall basis. Full joints on outside. Interior vertical spaces open)

Average volume of one brick in cubic inches	Cubic yards mortar required			
	¼-inch joint	5/16-inch joint	⅜-inch joint	½-inch joint
60	0.28	0.35	0.42	0.56
61	0.28	0.34	0.41	0.55
62	0.27	0.33	0.40	0.53
63	0.26	0.33	0.39	0.52
64	0.29	0.35	0.41	0.57
65	0.28	0.35	0.41	0.55
66	0.28	0.35	0.41	0.55
67	0.26	0.33	0.39	0.52
68	0.31	0.35	0.42	0.61
69	0.30	0.37	0.43	0.59
70	0.28	0.35	0.42	0.56
71	0.29	0.36	0.43	0.57
72	0.28	0.35	0.42	0.56
73	0.29	0.36	0.43	0.57
74	0.29	0.36	0.43	0.57
75	0.30	0.37	0.45	0.58
76	0.31	0.39	0.46	0.68

If all vertical spaces are filled solid with mortar, the above quantities must be increased 25 per cent.

Valuable Catalogue Information.—Several years ago a builders' supply dealer issued a catalogue and included in it some tables of valuable information. Among them was one giving the amount of materials required to make the necessary mortar to lay 1,000 bricks.

For a mixture of 1 part cement, 1 part lime-putty, and 3 parts sand, the catalogue gave the quantities as

0.36 barrel lime
0.75 barrel cement
0.32 yard sand,

which was based upon ⅜-inch mortar joints.

Comparing the table with the actual results reported from jobs upon which similar mortar and width of joint had been specified, and the quantities used were found to be as follows:

	Job 1	Job 2	Job 3	Job 4
Barrels lime...........	0.94	0.65	0.50	0.81
Barrels cement........	0.53	0.57	0.37	0.19
Yards sand............	0.43	0.55	0.47	0.49

It will be noticed that none of the jobs completed furnished a very good check upon the figures given in the catalogue.

The small quantity of cement used on Job 4 is explained by the use of a local grey lime, rich in alumina, which produces a very strong mortar even when the major portion of the specified quantity of cement is replaced by lime.

Variations in Lime.—The variation in the amount of lime used on the other three jobs is probably explained by the difference in the "bulking" capacities of the different brands of lime used. For instance, three different brands show a production of putty of 2.50, 2.62, and 2.75 times the amount of dry lump lime and authorities writing on the subject given an even wider variation. From the above, it would seem that, to get the actual proportions called for in the specifications, the quantity of dry lime used should never be more than 40 per cent of the quantity of cement used.

However, the great tendency is to exceed the specified amount of lime whenever possible because it produces a smoother working mortar, which means a saving in labor cost of bricklaying even though the cost per cubic yard of mortar may be slightly increased.

Regardless of the amount of the cementing materials used, the quantity of sand used is what determines the quantity of mortar produced and the figures indicate a variation of practically 28 per cent between Job 1 and

Job 2. Put in other figures, Job 1 used 400 cubic inches of sand per cubic foot of wall, while Job 2 used 510 cubic inches of sand per cubic foot of wall.

If the sand contained 33 per cent of voids, 3 cubic feet of sand and 1 cubic foot of cement should produce 3 cubic feet of mortar even if no lime were used; but, as the sand usually used will average from 40 to 50 per cent of voids, the addition of a cubic foot of lime-putty cannot increase the total volume beyond 3.70 to 3.80 cubic feet. In other words, the total volume of mortar cannot be over 1.27 times the amount of sand purchased. In actual practice, because of waste, shrinkage and other losses, the total quantity of mortar produced is very likely to be slightly less than the total amount of sand purchased.

Table 13.—Quantity of Ingredients per Cubic Yard of Mortar

(In the proportions column, cement is given first, lime-putty second and sand third)

Proportions	Barrels cement	Barrels of dry lump lime		Cubic yards loose sand
		180-pound basis	280-pound basis	
1-1-3	2.28	1.21	0.78	0.94
1-1-2	3.02	1.58	1.03	0.91
1-1½-3	2.28	0.61	0.39	0.94
1-1½-2	3.02	0.80	0.52	0.91
½-1-3	1.19	1.21	0.78	1.00
½-1-2	1.76	1.58	1.03	0.99
1-3 with 10 per cent lime-putty	2.28	0.13	0.08	0.94
½ with 10 per cent lime-putty	3.02	0.17	0.12	0.91

Even when the amount of mortar per thousand bricks is determined accurately for a given size of bricks, it will be

absolutely accurate only for a given thickness of wall. For instance, if a thousand bricks laid in a 12-inch wall required 0.55 cubic yards of mortar, varying the thickness of wall would affect the quantity of mortar approximately as follows:

	Per cent	Cubic yard
8-inch wall............	94	0.51
12-inch wall............	100	0.55
16-inch wall............	103	0.565
20-inch wall............	105	0.58
24-inch wall............	107	0.59

These differences are small, it is true, and on a small building would average up so as to balance one another, but, if costs were reported for a job having all 12-inch walls and those costs were used for estimating another one having all 24-inch walls, the difference might be appreciable. If a cubic yard of mortar costs $12, then the mortar for a thousand bricks in a 12-inch wall would cost $6.60 and in a 24-inch wall it would cost $7.08. On a million bricks this difference would be $480, well worth taking into consideration.

None of these tables has been carried beyond the second place of decimals. It is not believed that the accuracy attainable in scaling plans and computing quantities, or the accuracy attainable in measuring materials on construction work, will warrant any greater refinement.

Some of the figures in the table of Cubic Yards of Mortar Required per Thousand Bricks may seem inconsistent at first sight, but, by comparing these figures with those in the table of Bricks Required to Lay One Cubic Foot of Wall, and noting the volume of wall produced by 1,000 of a given size of bricks, the apparent inconsistency will be explained.

SECTION II. LABOR

In the previous section, dealing with the cost of the materials which are used in brickwork, it was shown why it is possible for there to be such great differences in two or more estimates submitted for the same piece of work.

Figures were presented to show the number of bricks of varying sizes required to lay up a cubic foot of wall and the amount of the mortar materials required for each 1,000 bricks of the size selected.

In the present section there will be presented a method of figuring the cost of brickwork labor. This method is the one that I have been using for years in my own work, and it has given highly satisfactory results.

The ideal method of estimating the cost of brickwork would be one which was worked out in as much detail as the method evolved by Taylor and Thompson for figuring the cost of concrete as presented in their book, "Concrete Costs."

Such a method would involve the finding and tabulation of the necessary unit-times for each such operation as picking the bricks from the pile, loading hods or wheelbarrows, delivering to scaffold, picking up, turning, placing, spreading mortar, cutting the joint, pointing, raising the line, plumbing corners and jambs, as well as a number of other operations.

Such a method would be very interesting from a theoretical viewpoint and might reasonably be used as means from which to develop more improved methods of handling brickwork, with ultimate reduction in cost.

Competitive Methods.—However, present competitive methods of doing business, as well as present labor conditions, make it impracticable to use such detailed methods, while good business demands that the method of estimating shall be one that gives a figure which will very closely approximate the actual cost of doing the work.

If, even considering the limited time usually allowed for the preparation of bids, the estimator could determine exactly the conditions under which the work will be conducted and the methods that will be used, he might be justified in using minutely detailed methods of estimating.

Often the estimator will have very little to do with the actual conduct of the work after a contract is closed, so the best that he can do is to exercise his good judgment as to the most desirable method of handling the work and estimate accordingly.

The method which has been outlined herein is intended to be sufficiently detailed for all practical purposes and yet not to be too theoretical. Certainly it is much better than the ordinary method of "sizing up" a job and setting a price per thousand bricks on that basis.

The quantities which have been set down herein as a normal hourly production for different classes of work were determined after a careful study of all the published literature, as well as by collating a great mass of personal experience data.

While the bricklayer's wages may not always be the largest single item in the cost of laying bricks, the number of bricks actually laid per man per hour is usually the determining factor in fixing the cost of the work.

Table 14 gives the average production that may be expected from competent bricklayers working under average conditions:

If there be more than the usual number of openings in the wall, or if there be many pilasters which require plumbing, an allowance of 5 minutes of bricklayer's time for each linear foot of plumbing should be made.

If joints on both sides of the wall must be struck, the production will be about 10 per cent less than the figures given above.

Just at present the actual production in the New England States will only run about 85 per cent of the tabular figures, but the proper kind of management should succeed in getting 100 per cent of those figures.

Other special and fancy bonds will decrease the production, as also will the introduction of many pilasters, openings, paneling, etc.

Laborers' Work.—The number of laborers, or tenders, required is, of course, determined by the number of bricks

being laid, the distance the bricks must be moved, necessity of culling bricks and other factors. The ratio may be anywhere from four laborers to each five bricklayers up to three laborers to one bricklayer.

The following information will be helpful in determining the number of laborers necessary:

One mortar mixer, working 9 hours, can produce about 4 cubic yards of sand-cement or sand-lime-cement mortar.

The cost of handling and storing cement for mortar is discussed in Chapter VI.

One laborer can load and wheel about 1,120 bricks a distance of 40 feet per hour, using barrows, and dump them on the scaffold.

Using a hod, he can make more trips but will probably only transport about one-half as many bricks per hour as he will with barrows.

One laborer can handle about 500 bricks per hour from car to wagon or from wagon to pile.

One laborer can cull from 200 to 300 bricks per hour, depending upon the quality of the bricks delivered and the stringency of the inspection.

One laborer, using a barrow, can deliver about 33 cubic feet of mortar a distance of 40 feet in one hour.

Two good laborers working together can handle about 16 linear feet of pole-staging per hour.

On thick walls one laborer can build, take down and move horse-scaffolding for twelve bricklayers. On thinner walls the work goes up more quickly so that more men are needed to build scaffolds. A fair ratio would be to decrease the number of bricklayers to each scaffoldman by two bricklayers for each decrease of 8 inches in thickness of wall below 3 feet. It is, of course, assumed that horse-scaffolding will not be used for any walls above normal story height.

It has not been attempted to include figures here for the great variety of patented scaffolds. The estimator who has occasion to figure on their use usually can get the necessary information from the manufacturers or from persons who have used them.

TABLE 14.—BRICKLAYING

(Hours time per 1,000 bricks)

	Masons		Laborers, tending[1]
	Using lime mortar	Using cement mortar	
Common brickwork:			
Joints struck 1 side walls 3 feet 0 inches thick and over	4.0	4.8	5.1
2 feet 4 inches to 2 feet 8 inches thick	4.8	5.3	5.1
1 foot 8 inches to 2 feet 0 inches thick	5.3	5.9	5.1
1 foot 4 inches thick	5.9	6.7	5.1
1 foot 0 inches thick	6.7	8.0	5.1
0 feet 8 inches thick	7.8	9.0	5.1
Backing stonework	7.8	9.0	5.1
Face brickwork:			
Running bond, plain-cut joints	10.5	11.2	6.8
V-joints	13.5	14.2	6.8
Raked out	13.5	14.2	6.8
Raked out and struck smooth	14.7	15.4	6.8
Flemish bond, plain-cut joints	14.7	15.4	6.8
V-joints	16.0	16.7	6.8
Raked out	19.3	20.0	6.8
Raked out and struck smooth	20.5	21.2	6.8
Rodded	21.5	22.2	6.8

[1] Figures in this column cover only serving bricks from pile to scaffold and mixing and serving mortar. The following costs, as required by the individual job, must be added:

Horse scaffolding, 8.5 hours laborers' time per 100 linear feet.

Pole scaffolding, 14.0 hours laborers' time per 100 linear feet.

Hoisting, 0.15 hour elevator time per thousand bricks per story.

Transporting, add 0.9 hour laborers' time for each 40 feet of horizontal travel, beyond the first 40 feet, from stock pile to point where bricks are laid.

Culling, 3.0 to 5.0 hours per 1,000 bricks.

Washing down, 1.0 hour mason and 0.5 hour laborer per 100 square feet.

Pointing inside faces of walls, 1.5 hours mason and 0.5 hour laborer per 100 square feet.

TABLE 15.—ACTUAL SIZES OF FACE BRICKS

	Length	Thickness	Width	Area of side, square inches	Volume, cubic inches	Average per square foot of wall
Standard.....	8.00	2.25	3.75	18.00	67.5	7
Selected sand struck.....	8.00	2.27	3.53	18.16	64.10	7.10
Water struck.	7.95	2.23	3.61	17.70	64.0	7.20
"Harvard"...	8.10	2.275	3.825	18.40	70.5	6.80
Pressed......	8.00	2.25	3.875	18.0	69.8	7
Enamelled....	8.125	2.25	4.00	18.3	73.2	6.90

TABLE 16.—HEIGHT OF SOLID AND IDEAL BRICKWORK BY COURSES.—(*Courtesy Common Brick Manufacturers' Association*)

(Based on standard brick 2¼ × 3¾ × 8 inches. Height from bottom of mortar joint to bottom of mortar joint)

Number of courses	⅜-inch joints				½-inch joints				⅝-inch joints				¾-inch joints		Number of courses
	Brick flat		Brick on edge		Brick flat		Brick on edge		Brick flat		Brick on edge		Brick flat		
	Feet	Inches	Feet	Inches	Feet	Inches	Feet	Inches	Feet	Inches	Feet	Inches	Feet	Inches	
1	..	2⅝	..	4⅛	..	2¾	..	4¼	..	2⅞	..	4⅜	..	3	1
2	..	5¼	..	8¼	..	5½	..	8½	..	5¾	..	8⅜	..	6	2
3	..	7⅞	1	0⅜	..	8¼	1	0¾	..	8⅝	1	1⅛	..	9	3
4	..	10½	1	4½	..	11	1	5	..	11½	1	5½	1	0	4
5	1	1⅛	1	8⅜	1	1¾	1	9¼	1	2⅜	1	9⅞	1	3	5
6	1	3¾	2	0¾	1	4½	2	1½	1	5¼	2	2¼	1	6	6
7	1	6⅜	2	4⅞	1	7¼	2	5¾	1	8⅛	2	6⅝	1	9	7
8	1	9	2	9	1	10	2	10	1	11	2	11	2	0	8
9	1	11⅝	3	1⅛	2	0¾	3	2¼	2	1⅞	3	3⅜	2	3	9
10	2	2¼	3	5¼	2	3½	3	6½	2	4¾	3	7¾	2	6	10
11	2	4⅞	3	9⅜	2	6¼	3	10¾	2	7⅝	4	0⅛	2	9	11
12	2	7½	4	1½	2	9	4	3	2	10½	4	4½	3	0	12
13	2	10⅛	4	5⅝	2	11¾	4	7¼	3	1⅜	4	8⅞	3	3	13
14	3	0¾	4	9¾	3	2½	4	11½	3	4¼	5	1¼	3	6	14
15	3	3⅜	5	1⅞	3	5¼	5	3¾	3	7⅛	5	5⅝	3	9	15
16	3	6	5	6	3	8	5	8	3	10	5	10	4	0	16
17	3	8⅝	5	10⅛	3	10¾	6	0¼	4	0⅞	6	2⅜	4	3	17
18	3	11¼	6	2¼	4	1½	6	4½	4	3¾	6	6¾	4	6	18
19	4	1⅞	6	6⅜	4	4¼	6	8¾	4	6⅝	6	11⅛	4	9	19

20	4	4½	6	10½	4	7	7	1	4	9½	7	3½	5	0	20
21	4	7⅛	7	2⅝	4	9¾	7	5¼	5	0⅜	7	7⅞	5	3	21
22	4	9¾	7	6¾	5	0½	7	9½	5	3¼	8	0¼	5	6	22
23	5	0⅜	7	10⅞	5	3¼	8	1¾	5	6⅛	8	4⅝	5	9	23
24	5	3	8	3	5	6	8	6	5	9	8	9	6	0	24
25	5	5⅝	8	7⅛	5	8¾	8	10¼	5	11⅞	9	1⅜	6	3	25
26	5	8¼	8	11¼	5	11½	9	2½	6	2¾	9	5¾	6	6	26
27	5	10⅞	9	3⅜	6	2¼	9	6¾	6	5⅝	9	10⅛	6	9	27
28	6	1½	9	7½	6	5	9	11	6	8½	10	2½	7	0	28
29	6	4⅛	9	11⅝	6	7¾	10	3¼	6	11⅜	10	6⅞	7	3	29
30	6	6¾	10	3¾	6	10½	10	7½	7	2¼	10	11¼	7	6	30
31	6	9⅜	10	7⅞	7	1¼	10	11¾	7	5⅛	11	3⅜	7	9	31
32	7	0	11	0	7	4	11	4	7	8	11	8	8	0	32
33	7	2⅝	11	4⅛	7	6¾	11	8¼	7	10⅞	12	0⅜	8	3	33
34	7	5¼	11	8¼	7	9½	12	0½	8	1¾	12	4¾	8	6	34
35	7	7⅞	12	0⅜	8	0¼	12	4¾	8	4⅝	12	9⅛	8	9	35
36	7	10½	12	4½	8	3	12	9	8	7½	13	1½	9	0	36
37	8	1⅛	12	8⅜	8	5¾	13	1¼	8	10⅜	13	5⅞	9	3	37
38	8	3¾	13	0¾	8	8½	13	5½	9	1¼	13	10¼	9	6	38
39	8	6⅜	13	4⅞	8	11¼	13	9¾	9	4⅛	14	2⅜	9	9	39
40	8	9	13	9	9	2	14	2	9	7	14	7	10	0	40
41	8	11⅝	14	1⅛	9	4¾	14	6¼	9	9⅞	14	11⅜	10	3	41
42	9	2¼	14	5¼	9	7½	14	10½	10	0¾	15	3¾	10	6	42
43	9	4⅞	14	9⅜	9	10¼	15	2¾	10	3⅝	15	8⅛	10	9	43
44	9	7½	15	1½	10	1	15	7	10	6½	16	0½	11	0	44
45	9	10⅛	15	5⅝	10	3¾	15	11¼	10	9⅜	16	4⅞	11	3	45
46	10	0¾	15	9¾	10	6½	16	3½	11	0¼	16	9¼	11	6	45
47	10	3⅜	16	1⅞	10	9¼	16	7¾	11	3⅛	17	1⅜	11	9	47
48	10	6	16	6	11	0	17	0	11	6	17	6	12	0	48
49	10	8⅝	16	10⅛	11	2¾	17	4¼	11	8⅞	17	10⅜	12	3	49
50	10	11¼	17	2¼	11	5½	17	8½	11	11¾	18	2¾	12	6	50
60	13	1½	20	7½	13	10	21	3	14	4½	21	10½	15	0	60
70	15	3¾	24	0¾	16	0½	24	9½	16	9¼	25	6¼	17	6	70
80	17	6	27	6	18	4	28	4	19	2	29	2	20	0	80
90	19	8¼	30	11¼	20	7½	31	10½	21	6¾	32	9¾	22	6	90
100	21	10½	34	4½	22	11	35	5	23	11½	36	5½	25	0	100

Elevating.—Two laborers, with a chain hod-elevator, can elevate 2,500 bricks a distance of 30 feet in 1 hour.

A two-barrow elevator, operated by a motor or steam engine, can elevate 10,000 bricks a distance of 30 feet per hour.

SECTION III. EXAMPLES

Example 1.—As previously stated, the quantities given herein are the average of a great number of published data and considerable personal experience. Actual production will vary very widely in different parts of the country and at different times.

Every estimator in active practice should have his own data book, covering the experience of his own organization, and those data will reflect the skill of the workmen employed as well as the organizing and executive ability of the foremen, superintendent, and higher officials.

However, by substituting the proper quantities and taking due account of all local conditions, this method of estimating may be used for practically every job.

As a typical example, we may take the case of an ordinary brick mill building, four stories high, with interior brick walls, enclosing the stairways. We will assume that the dimensions are 80 feet by 200 feet and the thickness of the walls as follows:

	Exterior, inches	Interior, inches
First story.........	20	16
Second story.......	16	12
Third story.........	16	12
Fourth story.......	12	12

Figuring the quantity of bricks by the usual method, and deducting all openings, we find that the job will require about 641,000 bricks, distributed as follows:

164,000 in 20-inch walls on first story
29,000 in 16-inch walls on first story
139,000 in 16-inch walls on second story
139,000 in 16-inch walls on third story
22,000 in 12-inch walls on second story
22,000 in 12-inch walls on third story
126,000 in 12-inch walls on fourth story

The method of computing the amount of mortar materials requires was explained in the previous chapter and will not be repeated here. This is to be an estimate of the labor cost only, and it will be assumed that the sand, cement and lime have been purchased for delivery at the site and that the bricks must be hauled from the siding 2 miles away over good earth roads and that teams are more readily available than motor trucks.

It will also be assumed that the stocks of lime, cement, sand and bricks will be disposed about 25 feet away from the building and that a steam elevator will be used:

Rates of pay are assumed as follows:

Bricklayers	$1.50 per hour
Laborers	0.70 per hour
Teams	1.50 per hour

Elevator—Flat-rate of $20 per day, including engineman, fuel, raising for additional stories, etc.

Horse-scaffolding will be used throughout, working from the floor construction and the outside bricks will be laid "overhand."

Evidently the first thing to do is to get the bricks from the siding to the site, so we will figure that cost first.

Since a laborer can handle 500 bricks per hour from car to truck or wagon, the cost is as follows:

Carting, from Table 7, 148.5 × 2.25 or 334 hours @ $1.50	$501.00
Loading, 200 hours @ $0.70	140.00
Total for 100,000 bricks	$641.00

Or $6.41 per 1,000 bricks, net cost, or $6.50 per 1,000 making a slight allowance for contingencies.

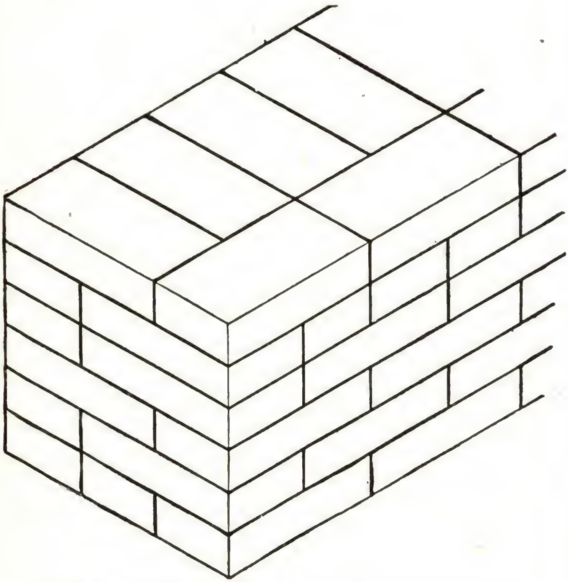

Fig. 1.—Twelve-inch brick wall—common bond.

It has been assumed that a sufficient number of teams will be employed to keep the men at the car busy, otherwise the time which they will lose while waiting for teams must be figured into the cost of the work.

In most places, it will be found practicable to employ lower priced men for such work as loading and unloading, and the figure above may be varied accordingly.

Fig. 2.—Common or running bond.

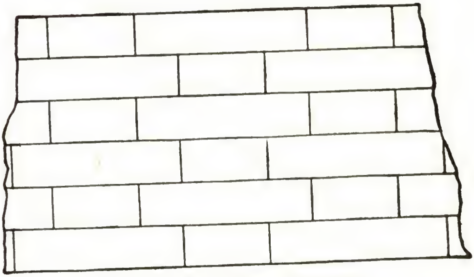

Fig. 3.—Flemish bond.

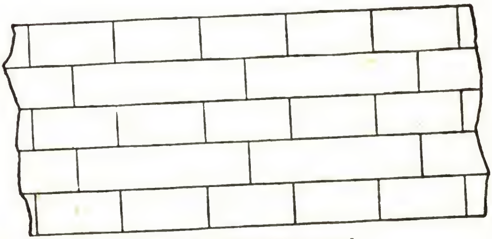

Fig. 4.—English bond.

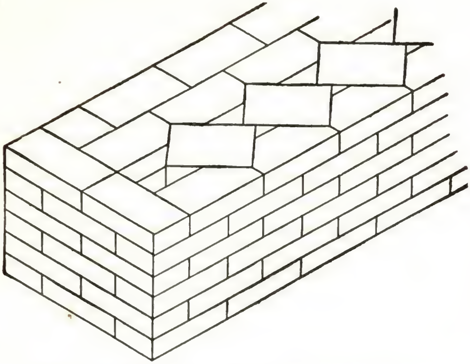

Fig. 5.—Common bond, clipped headers.

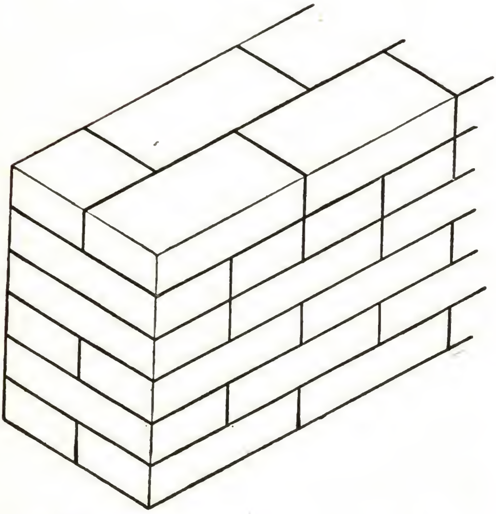

Fig. 6.—Eight-inch brick wall—common bond.

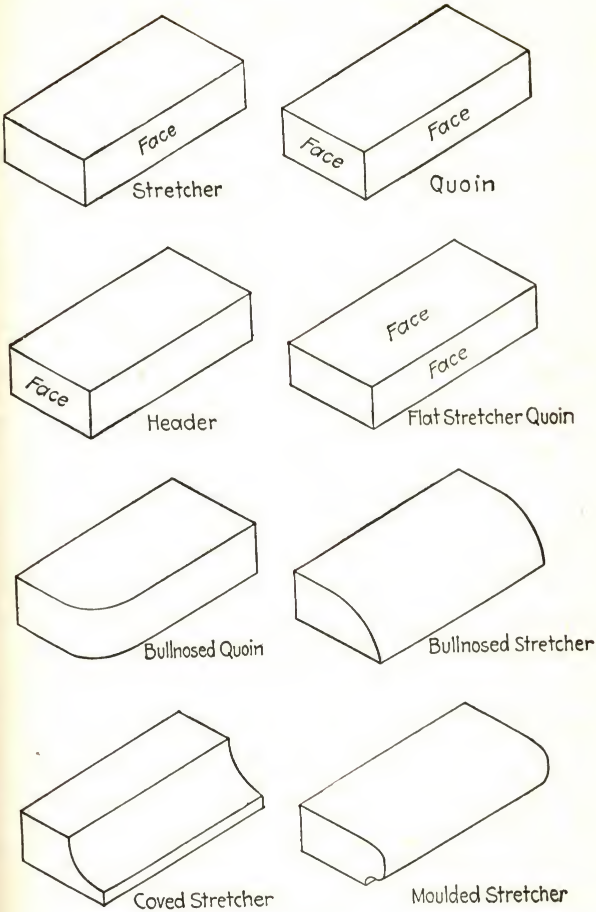

FIG. 7.—Some special shaped bricks.

From the method outlined in the previous section, we find that about 266 cubic yards of mortar will be required, to be used as follows:

86 cubic yards on the first story
65 cubic yards on the second story
65 cubic yards on the third story
50 cubic yards on the fourth story.

Because a job of this size will hardly tax the full capacity of the elevator, the cost of hoisting need not be figured separately for each floor but can be covered by a single item, as will be apparent later. Where a building is very high or the number of bricklayers great enough to use the full capacity of the elevator, it is well to estimate the amount of materials to be hoisted to the various heights and to figure accordingly.

From the locations of the piles and the dimensions of the building, it will be seen that the greatest horizontal distance that materials will be transported on the job is about 305 feet and the average about 165 feet.

The next item is the cost of building the scaffolding. Figuring three scaffolds per floor (if we can work from the floor planking, we shall only need two scaffolds per floor) above the first and two scaffolds on the first floor, we find that we need about 6,160 linear feet of scaffolding and it must be built, taken down and rebuilt as needed rapidly enough to keep the full number of bricklayers employed.

Therefore, we will figure on 524 hours of scaffold builders' time at 70 cents per hour or..........	$ 366.80
The cost of transporting the mortar from the mortar bed or mixer and the bricks from the piles to the scaffolds, an average horizontal distance of 165 feet, at the rate of 0.9 hour per 40 feet beyond the first 40 feet, (641 × 3.125 × 0.9) 1,810 hours @ 0.70.........................	1,367.00
plus the normal amount of time for the first 40 feet of horizontal distance, (641 × 5.1) 3,269 hours @ 0.70..............................	2,288.30

The actual laying of the bricks will be figured as follows:

20-inch walls 164 M × 5.9.	968 hours	
16-inch walls 307 M × 6.7.	2,057 hours	
12-inch walls 170 M × 8.0.	1,360 hours	
Total..................	4,385 hours @ $1.50	$6,577.50

On a job where the interior surfaces of the walls are to remain exposed, they must be pointed, which means an increase in the cost as follows:

26,880 square feet @ 1.5 hours per 100 or 403 hours @ $1.50..................................		$ 604.50
26,880 square feet @ 0.5 hours per 100 or 135 hours @ $0.70..................................		94.50
The job will run at least 35 working days, but allowing for rainy days or other delays, it is advisable to figure on at least 40 days time for the mason foreman, which at $16.00 per day would be..................................		640.00
Since all of the bricks above the first floor must be elevated, we must figure on using the elevator for 17 days, and this, at $20.00 will equal........		340.00
We now have a total of..........................		$12,278.60
for the labor cost of the job (which is an average of $19.10 per thousand) and to this must be added the cost of unloading and carting which, at $6.50 per thousand, equals..........................		4,166.50
The cost of washing down the outside walls of the building will be		
268 hours bricklayers @ $1.50.................		402.00
134 hours laborers @ 0.70....................		93.80
Compensation insurance		
3 per cent team hire..................	$ 98.05	
5 per cent on payroll..................	683.60	781.65
Or a total cost of..........................		$17,722.55

an average cost of $27.60 per thousand, to which must be added the cost of general supervision, building shanties, transportation of scaffolding, etc., any contingent items made necessary by seasonal and local conditions, office overhead and profit.

Extra Cost.—No attempt has been made to discuss, in the example just given, such items as cutting and grinding bricks for arches, building quoins or ornamental cornices, though proper allowance should be made for each such item made necessary by the design of the work. However, it is almost impossible to set down any figures which will be of real value without examining the design in each instance. A fair allowance is 0.17 hours of bricklayers' time for each brick that must be cut and ground and 0.17 hours of bricklayers' time for each running foot of each projecting or corbelled course. These amounts are to be added to the total cost of the work.

Shorter method.—A much shorter method of estimating and one which, while it is neither so accurate nor so detailed as the one just outline aboved, may be used when estimating time is limited, is given in the following paragraphs.

The job which we have just been considering may be called a "fair average" of what comes to the contractor who specializes in industrial buildings, and it brings out the following facts:

The total number of hours of bricklayers' time, inclusive of the extra pointing of inside walls, but exclusive of the time of foreman and the time spent in washing down exterior walls is 4,791, and the average number of bricks to be laid in each of those hours is 134, or 1,072 for an 8-hour day.

The total number of hours of laborers' time, exclusive of unloading, carting or cleaning down, is 5,738, or in other words, practically 9.6 hours of laborers' time for each 8 hours of bricklayers time. For convenience, we may call this an even 10 hours and, allowing for the foreman and elevator, we get the daily job cost for each bricklayer as follows:

8	hours bricklayer	@ $1.50.........	$12.00
10	hours laborer	@ 0.70.........	7.00
0.08	day foreman	@ 16.00........	1.28
0.03	day elevator	@ 20.00........	0.60
Total............................			$20.88

On a day's production of 1,072 bricks laid, this would equal $19.50 per thousand, or but a few cents more per thousand than the figure obtained by the more detailed method of estimating.

It must be remembered, however, that if we were using this latter method in actual practise, we should probably assume some arbitrary figure for the daily production, such as 1,100, 1,200, 1,300 or 1,400 bricks laid, and should then get the following costs per thousand, respectively, $19.00, $17.42, $16.10 or $14.93.

While the relative number of hours for the two classes of men will vary but little over a wide range of sizes of mill-type buildings, the daily production will vary widely and should always be calculated as closely as circumstances will permit.

The amount of foreman's time and elevator time will be governed largely by the number of men that can be employed and that number, in turn, by the size of the building and other conditions, and these two items may vary as much as 50 cents to one dollar per thousand in the cost of the bricks.

Whichever method of figuring is used, the cost of culling bricks for facing, when such is necessary, must be added. Of course, in all instances, the actual rates of wages which will prevail on the job to be estimated must be used in making up the figures.

Example 2.—Where pressed or face bricks are used, or in any case where "over-hand" laying of the outside facing will not be permitted, it will be necessary to figure upon two scaffolds, an inside scaffold of the "horse" type for laying the backing and an outside scaffold of the pole or swing type for laying the facing.

When pressed bricks are used, their added weight, and the greater care required in handling them, will reduce the number which can be handled by laborers in a given time to only two-thirds or three-fourths of the number of common bricks which could be handled in the same time.

For instance, if the building under consideration had been faced on one side and one end with pressed bricks,

the total quantities involved would then have been as follows:

69,000 pressed bricks
82,000 common bricks in 20-inch walls
234,000 common bricks in 16-inch walls
211,000 common bricks in 12-inch walls
45,000 common bricks in 8-inch walls

and the estimated time for laying them will be as follows:

69 M pressed bricks @ 11.2 hours	773 hours
82 M common bricks in 20-inch walls @ 5.9 hours	484 hours
234 M common bricks in 16-inch walls @ 6.7 hours	1,568 hours
211 M common bricks in 12-inch walls @ 8 hours	1,688 hours
45 M common bricks in 8-inch walls @ 9 hours	405 hours
Total	4,918 hours

The cost of hoisting will be practically the same as before. The cost of hauling the common bricks will not be changed, but it will cost more to haul the face bricks, they must be unloaded and piled and cannot be dumped.

The cost for handling 100,000 face bricks from car to site will be

Carting, Table 7, 148.5 × 2.93 or 435 hours @ $1.50	$ 652.50
Loading 300 hours @ 0.70	210.00
Unloading and piling 300 hours @ 0.70	210.00
Total	$1,072.50

or $10.73 per thousand.

The cost of the laborers attending the bricklayers, assuming that the locations of stock piles with reference to the work are as before, will be changed only by the added time normally necessary on account of the greater care needed in handling pressed bricks (this equals 1.7 hours per 1,000 bricks) and the labor necessary for the construction of the outside pole scaffolds, of which 3,080 linear feet, requiring 14 hours per 100 linear feet, or 431 hours time, will be required.

A summary of the cost under these conditions will therefore be as follows:

Carting 572 M common brick @ $6.50			$ 3,718.00
69 M pressed bricks @ 11.00			759.00
4,918 hours bricklayers' time @ $1.50			7,378.50
Laborers' time:			
As in previous estimate,	5,603		
Extra a/c face bricks 69 M × 1.7	117		
Building outside scaffold	431		
	6,151 hours @ 0.70		4,305.70
Hoisting as before			340.00
Pointing inside face as before			699.00
Wash down outside as before			495.80
Foreman as before			640.00
Compensation insurance:			
3 per cent on team hire		$ 99.30	
5 per cent on pay roll		750.00	849.30
Total			$19,185.30

to which must be added any incidental and contingent items, overhead expense and profit, as previously explained.

Of course, if desired an entirely separate estimate could be prepared for the face bricks and the common bricks, but the same methods of procedure would be used.

Patented Scaffolds.—On buildings having a skeleton frame greater convenience in operation and some economy in cost can be attained through the use of swinging and other types of patented scaffolding. In most instances, these scaffolds are owned by companies who install them on a rental basis and, where there seems to be an opportunity to use such a scaffold, it is recommended that a proposal be obtained from the nearest company or agency engaged in that work.

CHAPTER IV

STONE WORK, CEMENT BLOCK WORK, ARCHITECTURAL TERRA-COTTA

SECTION I. STONE FOUNDATIONS. RUBBLE STONE

While it is true that stone foundation work has been almost entirely superseded by concrete in many parts of the country, it is essential that the well-informed estimator be familiar with the methods of figuring its cost.

It is also improbable that the time will ever come when there will not be some call for high-grade jobs of rubble stone work, because no other form of construction can produce the same variety of artistic effects.

Since the range of sizes and shapes of stones available for rubble stone work will vary widely, and hardly any two lots of stone will work out alike, it is not practicable to develop as detailed, or as accurate, a method of estimating rubble stone work as is practicable for cut stone work, brickwork, or for concrete work.

This makes it necessary to resort more to the method of assumptions than when estimating brickwork or concrete, but nevertheless the estimator should strive to accumulate all the experience data that he can, taking care to record his data so that they can readily be used for the purpose of estimating those features of any new work that are comparable with similar features of previous work.

Every estimator will do well to record the cost, in man-hours, of the various operations on any rubble stone job coming under his observation and to compare it with the information contained in this section.

In this portion of New England, it is quite usual to build stone foundations from old stone fence-walls and, when this

is done, the question of estimating the cost of obtaining the stones is very simple.

In other cases, when it is necessary to obtain the stones from the field, the cost can only be obtained by determining, as nearly as possible, the necessary time required to assemble them into piles and load them into the carts or wagons, and this time will be determined by the frequency or scarcity of stones in the field that are suitable for use in the work.

Where the stones can be taken from a gravel-pit or from a fence-wall and the sizes are such that they can be loaded by hand, the following figures may be used:

TABLE 17.—HANDLING STONES
(Labor hours per cubic yard)

	From pit to wagon or truck	From old stone fence walls to wagon or truck
Small round cobbles or boulders	0.72	0.66
Large round cobbles or boulders	0.78	0.70
Small split stones	0.67	0.60
Large split stones	0.73	0.65

NOTE.—Figure hauling as in Table 7, Chapter II, on basis of 2,600 pounds per cubic yard or 0.78 cubic yard per ton. Where wheeling is necessary, add 1 hour per cubic yard per 100 linear feet of distance wheeled.

Allowance for Openings.—When figuring the quantity of stone and mortar required, allowance may be made for the various openings in the wall and the actual cubical contents taken but, when figuring the cost of the labor, it is well to remember that stonemasons who take rubble-stone work by sub-contract usually insist upon measuring entirely around the outside of the foundation and not allowing for any ordinary openings.

They usually also insist upon figuring upon a minimum thickness of 18 inches, no matter what the actual thickness of the wall may be.

This is done because there is practically no available data as to the cost of building jambs and corners, so the assumption is made that the saving by reason of the openings will balance the added cost of the jambs and corners. It is also assumed by the masons that it takes just as long to build a wall 12 inches thick as it does to build a wall 18 inches thick, because of the greater care required in selecting stones and plumbing the wall.

The discussion of the cost of producing mortar for brickwork, given in Chapter III, applies equally to the cost of producing mortar for stonework whether it be rubble-stone or cut stone.

Scaffolding for all walls over 4 feet in height must be figured as explained in Chapter III and added to the costs obtained from these figures.

It was formerly the custom to pay for stonework by the perch, and that unit is still in vogue in many parts of the country, but just what constitutes a perch seems to be subject to some disagreement. The most commonly accepted definition is 16.5 square feet of 18-inch wall, or 24.75 cubic feet.

For this reason the cubic yard is recommended as the most satisfactory unit for use in figuring rubblestone work.

In the section on stone setting we go into a great deal of detail as to the methods to be employed in estimating the cost of setting cut stone, ashlar facings, and other ornamental work, as well as the use of hand and power derricks in stonesetting.

However, estimators are called upon to figure stone foundations in which it is necessary to split the stones and square them roughly for laying, either in coursed or random ashlar or in cobweb rubble.

Of course, the more nearly rectangular in shape the stones are, the less mortar will be required for laying with a given thickness of joint and the amount required will also be less as the size of the individual stones increases.

Tables 18, 19 and 20 will give the time necessary to prepare the stones and lay them.

When the individual stones run much over one-half cubic foot each, it will be necessary to set them with a derrick. For most ordinary work a hand derrick will give very efficient service, but on large operations a power derrick can be employed.

In another chapter the methods used in figuring the charge for power equipment are discussed, so it is only necessary for the present to consider the cost of the direct labor, foreman, water-boy, etc.

TABLE 18.—BUILDING STONE WALLS
(Using one- and two-man stone)

	Required per cubic yard			
	Wall 18 to 30 inches thick		Wall 30 to 48 inches thick	
	Flat split stone	Cobbles	Flat split stone	Cobbles
Masons, hours	2.5	6.25	1.75	5.25
Laborers, hours	2.5	5.25	2.5	5.25
Cubic yards mortar	0.26	0.30	0.26	0.30

NOTE.—Figure scaffolding as indicated for brickwork. Figure extra wheeling, when more than 40 feet from stock pile to work, as indicated for handling stones.

TABLE 19.—BUILDING WALLS OF PREPARED STONES
(Hours of cutters' time per 100 square feet of surface prepared)

	Freestone	Granite
Hammered faces	80.0	100.00
Beds and builds	40.0	50.00
Fine hammering	200.0	250.00

NOTE 1.—Add cost of rough stone, figured at proper price per ton or yard, see Table 28.

NOTE 2.—For jobs of fine stonework, prices should always be obtained from quarries or yards equipped to deliver the stone at the site of the work, ready for setting.

TABLE 20.—LAYING WALLS OF PREPARED STONES
(Required per cubic yard of wall)

	Cobweb rubble	Random ashlar	Coursed ashlar: Courses up to 18 inches high	Coursed ashlar: Courses 20 to 32 inches high
Mason, hours	6.25	7.0	6.0	5.25
Laborers, hours	4.75	5.0	6.0	5.25
Cubic yard mortar	0.15	0.15	0.15	0.20

NOTE.—Figure scaffolding as for brickwork. Figure extra wheeling, when more than 40 feet from stockpile to work, at 2 hours per cubic yard per 100 linear feet.

In addition to the actual cost of laying the stones in the wall, a very important item in the cost of stone-work is that of pointing the exposed areas and, since the kind and quality of work demanded varies greatly, the cost varies accordingly. Table 21 gives the data necessary for computing the cost of the labor.

TABLE 21.—POINTING STONE WALLS
(Hours per 100 square feet)

	Mason	Laborer
Flat stone work, joints raked out	5.0	1.67
Small cobble work, joints raked out	5.0	1.67
Large cobble work, joints raked out	3.33	1.12
Random ashlar	3.33	1.12
Cobweb rubble, joints raked out	3.33	1.12
Coursed ashlar	3.33	1.12
Cobweb rubble, smoothed joints	5.0	1.67
Random ashlar, smoothed joints	5.0	1.67
Coursed ashlar	5.0	1.67
Cobweb rubble, ribbon joints	10.0	3.33
Random ashlar, ribbon joints	10.0	3.33
Coursed ashlar, ribbon joints	10.0	3.33

Example.—Assume that the foundation for a church building is to be 80 feet long, 40 feet wide and 10 feet high. The first 6 feet from the bottom of the wall to grade are to be ordinary flat stone work, but from grade to top is to be coursed granite ashlar. The outside walls above grade are to be pointed smooth and the inside face from bottom to top is also to be pointed smooth. The wall is to be 2 feet thick.

The flat stones are available on the lot but the granite is delivered at a railroad station a mile away. The mortar materials are furnished at the job, which is quite a usual practice in some sections of the country where stonework is sublet by general contractors to men who specialize in stone setting.

The wages per hour are

Masons	$1.50
Laborers	0.70
Team and wagon	1.50

The quantities involved are evidently as follows:

Perimeter of wall equals 240 linear feet, therefore, the flat stone work is 240 feet by 2 feet by 6 feet or 2,880 cubic feet, say 107 cubic yards, and the ashlar is 240 feet by 2 feet by 4 feet or 1,920 cubic feet, say 72 cubic yards of ashlar. The area to be pointed is

Inside 224 feet by 4 feet	896 square feet
Outside 240 feet by 4 feet	960 square feet
While the area of rubble to be pointed is 224 feet by 6 feet	1,344 square feet
Making the total area to be pointed	3.200 square feet

The time required will be as follows:

Masons, laying flat stone 107 yards @ 2.5	267.5 hours
laying ashlar 72 yards @ 6	432
pointing 3,200 square feet @ 5 hours per 100	160
Total	859.5 hours, say 860
Laborers, on flat stone, same as masons	267.5 hours
on ashlar, same as masons	432
on pointing, @ 1.67 per 100 square feet	53.5
on pole scaffolding, 240 linear feet @ 14 hours per 100	33.6
Total	786.6 hours, say 787

From Table 7 assuming good macadam road, a two horse team and a weight of 170 pounds per cubic foot for the granite, we get the hauling time as follows:

1,920 cubic feet × 170 pounds equals 326,400 pounds or 168.2 tons

which would figure out thus:

0.70 × 80 hours × 1.682 equals 94.26 hours, say 95

and at 4 hours per 100 cubic feet for loading the wagon and the same amount for unloading, we would have

19.2 × 8 or 153.6 hours, say 154

Summarizing:

860 hours mason time @ \$1.50	\$1,290.00
787 hours laborer time @ \$0.70	550.90
95 hours team time @ \$1.50	142.50
154 hours laborer time loading, etc.	107.80
Total	\$2,091.20

which equals practically \$10.30 per cubic yard exclusive of the hauling, loading and unloading, and \$1.40 per cubic

yard for those items; or on a cubic foot basis, practically 40 cents and 5½ cents respectively.

To the cost just found must be added any premium which it may be necessary to pay to one of the masons for acting as foreman, the cost of compensation insurance, moving scaffolding to and from the job, overhead expense and profit, all as explained in earlier examples in this book.

From the tables it is evident that 38.4 cubic yards of mortar will be required, and a complete estimate of the cost of the work would include all of the costs above, the cost of the mortar materials and the price of the granite at the depot.

SECTION II. CEMENT BLOCK WORK

The most common size of block used is 8 inches thick, 16 inches long, and 8 inches high, and it weighs from 50 to 60 pounds, depending upon the percentage of core-voids and the density of the concrete used. Blocks 12 inches long and 8 inches high, as well as other shapes, are also used but not so extensively as the 16 inch by 8 inch size.

In addition to the "stretcher" blocks, it is necessary to have corner and jamb blocks, as well as lintels. On the better jobs, short stretchers will be provided to make closures.

Various methods of organizing are used for cement block work, but the most satisfactory method seems to be to have a helper for each mason, to assist in lifting the blocks onto the wall, and one man to mix mortar and serve it to each two masons.

Additional men will be required to bring the blocks from the piles and distribute them along the wall, since the helper cannot be expected to handle them for a greater distance than 10 feet without delaying the mason.

Makers of cement-block machinery and dealers in the blocks consider about 260 blocks, including jambs and corners, to be a fair amount to lay in an 8-hour day. The figures in our table are more conservative.

TABLE 22.—LAYING CEMENT BLOCKS
(Time in hours per 100 blocks)

Mason	3.8
Helper	3.8
Mortar-man	1.9
Wheelers (per each 100 feet distance to pile)	0.8
Loading or unloading trucks, laborers' hours	0.5
Add for each linear feet of corner or jamb to plumb, masons' hours	0.06
Adding for each linear foot of ornamental projecting corners, masons' hours	0.05
Mortar, cubic yards	0.2

This table will hold good for walls up to 12 feet in height, but, since cement-block walls are seldom used for buildings having a greater story height, it is not necessary to compile a table for greater heights. When the building is more than one story high, allowance must be made for elevating, as explained in brickwork.

The time for loading onto or unloading from wagons or trucks is given in the table, and knowing the weight of the blocks, you can compute the cost from the knowledge you have gained in studying the previous chapters.

Examples.—Assume that we have a building 200 feet long, 70 feet wide, and 12 feet high, with 48 steel-sash each 6-0 by 8-6, 2 doors 10-0 by 10-0, and 3 doors 3-0 by 7-0, and we wish to compute the labor cost of laying the blocks.

The wall area is evidently:

(2) by 200 = 400
(2) by 70 = 140
540 linear feet by 12 feet high....... 6,480

less

(48) by 6-0 by 8-6........	2,448	
(2) by 10-0 by 10-0.........	200	
(3) by 3-0 by 7-0...........	63	2,711
	square feet	3,769

Disregarding the thickness of the joints 3,769 × 144 ÷ 128 = 4,240 blocks required

Assume laborers' rate........... $0.45 per hour
Assume masons' rate........... 0.90 per hour

Blocks delivered by trucks to site and unloaded 100 feet from working point.

For each 100 blocks the time to be consumed at the job is, therefore, as follows:

Laborers:

	Hours	
Unloading	0.5	
Wheeling	0.8	
Mortar-man	1.9	
Helper	3.8	
	7.0 @ 0.45	$3.15
Mason:	3.8 @ 0.90	3.42
Cost to lay 100 blocks		$6.57

But we must add the cost of plumbing the corners and jambs, which is,

	Linear Feet
4 corners @ 12 feet	48
96 window jambs @ $8\frac{1}{2}$ feet	816
4 door jambs @ 10 feet	40
6 door jambs @ 7 feet	42
	946 @ 0.06 = 56.76 hours

4,240 blocks laid @ $6.57 per hundred	$278.57
57 hours time plumbing corners, etc. @ 0.90	51.30
Total labor cost	$329.87

If we use a mortar made of 1 part cement, 3 parts sand and 10 per cent lime putty, the cost of the mortar materials would be figured as follows:

2.28 barrels cement @ $2.80	$6.38
0.08 barrels lime @ $4	0.32
0.94 cubic yards sand @ $1.25	1.18
Per cubic yard	$7.88

4,240 blocks @ 0.2 cubic yard per 100 = 8.48 cubic yards

8.48 cubic yards @ $7.88 .... $66.82

The cost of scaffolding is figured as indicated in Chapter III.

TABLE 23.—WEIGHTS OF CEMENT BLOCKS

Thickness, inches	Cinder blocks		Sand concrete blocks	
	Pounds per square feet	Square feet per ton	Pounds per square foot	Square feet per ton
8	40	50	70	28.6
12	70	28.6	105	19
			Pounds per block	Blocks per ton
8	..	....	60	33.4
12	..	....	85	23.6

SECTION III. MAKING CEMENT BLOCKS

No attempt is made here to cover completely the method of estimating the cost of producing the blocks, since they are usually made in factories and delivered to the job at a fixed price per block. However, a few words on the subject will not be inappropriate.

The cost of making the blocks varies widely with the equipment used; thus of two apparently prosperous plants I recently visited, one, using mechanical tampers, mechanical conveyors, industrial cars, etc., with a gang of eight men, working 9 hours per day, turns out an average of 3,300 dry-tamped blocks per day. The other plant, with all hand operations and a gang of three men at work, turns out 700 similar blocks per week.

Assuming a labor rate of 45 cents per hour, which is probably higher than actually paid, their costs would be as follows:

Mechanical plant, 8 by 0.45 by 9 ÷ 3,300 = 1 cent per block
Hand plant, 3 by 0.45 by 9 by 6 days ÷ 700 = 10.41 cents per block

The cost of the materials used depends entirely upon the mix used, and most block-makers are not very definite in stating what mix they use. However, this may be roughly estimated by assuming that the usual mix is not much higher than 1 to 5, which requires 1.20 barrels of cement and 1 yard of sand per cubic yard.

Thus:

1.20 barrels cement @ $2.80	$3.36
1 cubic yard and @ $1.25	1.25
1 cubic yard mortar will cost	$4.61

Since each block of the size under consideration contains 704 cubic inches of mortar, a yard will make 27 times 1,728 ÷ 704 = 66.2 blocks, which would mean that the material cost of each block would be approximately 7 cents.

Assuming usual overhead costs, the comparison of the two plants will be as follows:

	Mechanical Plant	Hand Plant
Materials	0.07	0.07
Direct labor	0.01	0.104
Overhead (50 per cent of labor)	0.005	0.05
Total	0.085	0.224

Whenever occasion requires the making of an estimate of the cost of producing cement blocks, it is essential to get complete data as the equipment available, mixture to be used, size and cross-section of blocks, and all other factors which affect the cost.

Care should also be taken to differentiate between dry-tamped blocks and wet-poured blocks.

SECTION IV. ARCHITECTURAL TERRA-COTTA

In estimating the cost of setting all sorts of ornamental work, as well as natural stone ashlar, the cubic foot seems to be the most satisfactory unit of calculation and as a basis in figuring architectural terra-cotta, though others

figure it by the square foot of surface area and some by the ton. The individual block seems to be the most satisfactory unit for figuring cement block work.

One "Estimators' Hand-book" says that "architectural terra-cotta is of special design and has to be figured accordingly." That is very enlightening except that the book does not tell how to figure it accordingly.

Architectural terra-cotta is essentially a manufactured product and the matter of estimating the cost of production is no more within the province of the construction estimator than is estimating the cost of producing any other manufactured article.

It is true that the man who has carefully kept the data as to the cost of terra-cotta on previous jobs is in a position to approximate the cost of similar jobs in the future. However, the price of terra-cotta is varied by so many factors, such as finish, amount of ornament, number of times any piece is duplicated, color, etc., etc., as well as manufacturing conditions and transportation costs, that it is always wise to get a definite quotation based upon the plans and specifications in every case.

Such a quotation may or may not include all necessary anchors. If it does not, then it is necessary to secure a list of those anchors from the manufacturers, or from the architect or the plans, and secure a price for them. When a lump-price for the anchors is not obtainable, their weight can readily be calculated by the tables in structural steel hand-books and their cost estimated at the current price for builders' wrought iron work.

Terra-Cotta Like Cut Stone.—Setting architectural terra-cotta is an operation very similar to setting cut-stone work, except that its lighter weight usually obviates the necessity for using derricks with terra-cotta and, in those sections where the trades are separated, terra-cotta is more usually set by bricklayers than by stone-setters. When any fitting is necessary at the job that also is done by bricklayers, generally by those who are particularly expert in the work, rather than by stone-cutters.

On work involving any large amount of terra-cotta, it is well to make sure that the price made by the manufacturer includes the cost of necessary fitting to take care of any inaccuracies in the dimensions of the several pieces. It is hardly practicable for the builder to estimate the cost of fitting, since it may be absolutely nothing on one job and run to several hundred dollars on another and similar job.

When scaling quantities of terra-cotta from plans, it is necessary to take the full "squared" size of all mouldings, projections, capitals, columns, and similar members and multiply the dimensions into cubic feet. On that basis, the average weight will be between 70 and 75 pounds per cubic foot and the cost of hauling may be figured accordingly.

The cost of the scaffold, when figured separately, may be computed according to the data given in the discussion of brickwork. There will be many times when the terra-cotta will be laid from the same scaffold as that used for the bricklaying, so no separate item need by made.

The cost of handling the terra-cotta from car to truck, truck to wheelbarrows, to the building, sorting and distributing it, as well as setting and cleaning down, may be computed from the following tables:

TABLE 24.—UNLOADING TERRA-COTTA
(Labor hours per 100 cubic feet)

From car to truck	3
From truck to barrow	3
Wheeling 100 feet	3
Sorting and distributing	8
Elevating, per story, time of elevator	1.0

NOTE 1.—Figure hauling on basis of table on page 12, using 75 pounds per cubic feet, or 28 cubic feet per ton.

NOTE 2.—In estimating terra-cotta quantities, take greatest dimension in each direction.

TABLE 25.—SETTING AND BACKING TERRA COTTA
(Requirements per 100 cubic feet)

	Setting terra cotta	Backing with bricks
Mason, hours	8	8
Laborer, hours	10	4
Mortar, cubic yard	0.16	
Bricks	....	80

TABLE 26.—CLEANING AND POINTING TERRA COTTA
(Time per 100 square feet of exposed surface)

	New work		Old work	
	Washing down	Pointing	Cleaning	Pointing
Mason, hours	1.5	1.5	2.0	2.0
Laborer, hours	0.75	0.75	1.0	1.0

NOTE.—To the cost of setting and pointing must be added the cost of unloading and distributing, also the cost of such scaffolding as may be necessary.

SECTION V. CUT STONE WORK

As with architectural terra-cotta, the production of cut-stone has become a manufacturing proposition and is seldom undertaken by a general contractor.

We shall therefore limit ourselves to discussing how to estimate the cost of installing the stone in the building, as that is all that the building-estimator generally finds it necessary to estimate himself.

Usually when there is any appreciable amount of stone to be used in a building, the companies bidding on it will name a lump-sum figure for all of the stone required. They will also give their estimate of the number of cubic feet to be set, thus relieving the general contractor of the

necessity of scaling the quantities again, unless he desires to check the figures.

TABLE 27.—UNLOADING CUT STONE
(Labor hours per 100 cubic feet)

	By hand	By hand derrick	By power derrick or crane
Car to truck or wagon	4.0	3.0	2.5
Truck or wagon to barrow	4.0	3.0	2.5
Wheeling in barrows per 100 linear feet	3.0		
Elevating, per story,[1] time of elevator	3.0		

[1] This figure only applies where the stone is used on upper stories and is raised to the floor by elevator instead of being lifted directly to its location by derrick.

There are many items of stone-work, such as sills, lintels, pier-caps, chimney-caps, steps, bond-stones, etc., upon which it is possible to secure unit price lists in many localities, and when this is possible, it is well to be equipped with such lists and use them in estimating, even though the figures may be checked by sub-bids.

When using such lists, it is well to be very careful to make sure that the list covers exactly the same sizes, kinds of finish, etc., that are called for by the plans and specifications, as it is possible that there may be a very appreciable variation otherwise.

When any special work or ornamentation at all is required, it is very necessary to get special prices.

The cubic foot, as previously stated, is the most convenient unit for use in figuring stone-work but, of course, the number of cubic feet that can be handled in a unit period of time will be determined by the size and weight of the individual pieces, their shape, and their position in the work.

Such items as sills, lintels, steps, pier-caps, etc., are usually set by hand, one or more laborers assisting the

mason as may be required, but when ashlar facing is used, or when very much ornamental work, such as columns, cornices, etc., is included, it is customary to use a small hand-derrick or a breast-derrick.

Profitable Use of Derrick.—Where the individual pieces are heavy, or where the total quantity to be handled runs into several thousand feet, it may be profitable to use a power derrick. However, this should be studied carefully, because it often develops that the mason will not handle the stone rapidly enough to pay the added cost of the power equipment and the men to run it, to say nothing of the cost of installation, fuel and removal.

The information given in Chapters II, III and VI will enable the estimator to figure the cost of hauling, scaffolding, elevating, etc. The cost of loading and unloading will be determined by the facilities available. (See Table 27.)

If the stones are large, and no derrick is available for moving them from the car to truck and truck to building, the cost will naturally be higher than where the unloading facilities are good or the stones small.

The following tables contain the information necessary for the preparation of an estimate on any ordinary work.

TABLE 28.—WEIGHTS OF BUILDING STONES

	Pounds per cubic foot	Cubic feet per ton
Granite	170	11.7
Limestone	160	12.5
Sandstone	164	12.2
Bluestone	151	13.2
Marble	168	11.9
Gneiss	168	11.9
Slate	175	11.4

TABLE 29.—SETTING CUT STONE
(Hours per 100 cubic feet)

	Masons	Laborers	Derrick[1]
Hand work:			
Sills, lintels, etc.	30.0	30.0	
Ashlar	12.0	20.0	
Small cornices, etc.	20.0	30.0	
Using hand derrick:			
Sills, lintels, etc.	24.0	24.0	
Ashlar	10.0	20.0	
Small cornices, etc.	15.0	30.0	
Using power derrick:			
Heavy foundation stone	4.0	32.0	4.0
Ordinary ashlar	8.0	48.0	4.0
Ornamental work	12.0	36.0	4.0

[1] This rate to include cost of derrick, power, and operator.

NOTE.—For heavy stonework, figure pole scaffolding at 1.5 times the cost of scaffold for brickwork.

TABLE 30.—MORTAR FOR CUT STONEWORK
(Cubic yards per 100 cubic feet stone)

	Setting	Pointing	Parging
Heavy foundations	0.10	0.03	
Thin ashlar	0.15	0.05	0.15
Sills, lintels, etc.	0.15	0.05	0.15
Ornamental work	0.13	0.04	0.13

TABLE 31.—CLEANING AND POINTING CUT STONE
(Hours per 100 square feet of exposed surface)

	New work		Old work	
	Washing down	Pointing	Cleaning	Pointing
Mason........	2.0	2.0	3.0	3.0
Laborer.......	1.0	1.0	1.5	1.5

Most architectural stone-work must be laid in non-staining mortar, the composition of which is usually definitely specified by the architect. It is becoming customary to use White Portland Cement as the binding principle in non-staining mortars and when this is done, the tables given in the chapter on brick-work can be used in figuring the cost of the mortar, taking due account of the fact that the price of white cement is very much higher than that of the standard grey color.

The quantity of mortar required can be calculated from Table 30.

Beside the cost of hauling, labor, elevating and mortar, it is necessary to include the cost of all anchors and clamps that are specified, being careful to note the number and kind as well as the material of which they are to be made and to get proper prices for them.

After the setting has been completed it will be necessary to wash the work down, using no acid for most stones, and the cost of such cleaning is to be calculated as in Table 31.

On work which has been exposed to weather for many years, particularly in communities where much soft coal is used, an ordinary washing down, even with a strongly alkaline wash, will not restore the stone to a satisfactory appearance.

It is then necessary to resort to the use of a sandblast and the work is usually done by "stone-renovators" rather than by builders.

Example 1.—Assuming for example a building front, to have a granite grade-course and a limestone-ashlar facing

with the usual amount of ornamental work, such as pilasters, caps, bases, cornices, etc.

The bill of quantities, using the method mentioned in the discussion of architectural terra-cotta, and taking the "squared" dimensions of all members, is assumed as follows:

	Cubic Feet
Granite grade course	120
Limestone ashlar	720
Sills and lintels	150
Ornamental features	600
Total	1,590

Assume that the stone is to be delivered f.o.b. cars at the railroad station, one mile from the job over good hard roads, there is ample room at the work to pile the stone, but as the building is three stories high, it will be necessary to hoist our stones by a power derrick which will be located at a point that will serve the entire front and obviate the necessity for re-locating during the work.

To calculate the cost of bringing the stone from the railroad to the building, use Table 28.

The total weight is, therefore:

120 cubic feet granite @ 170 pounds	20,400
1,470 cubic feet limestone @ 160 pounds	235,200
	255,600 pounds

or 127.8, say 128 tons.

Using a 2-ton truck, we find from Table 7, that the cost per 100 tons will be 17.4×0.75 or 13.05 hours per 100 tons, equalling 16.70 hours, say 17 hours for 128 tons.

The time for unloading at car and from truck at site, at 4 hours per 100 cubic feet for each of those operations, will total 127 hours.

The cost of the derrick engineer will be included in the flat rate for the derrick and figured into the setting as indicated on page 67.

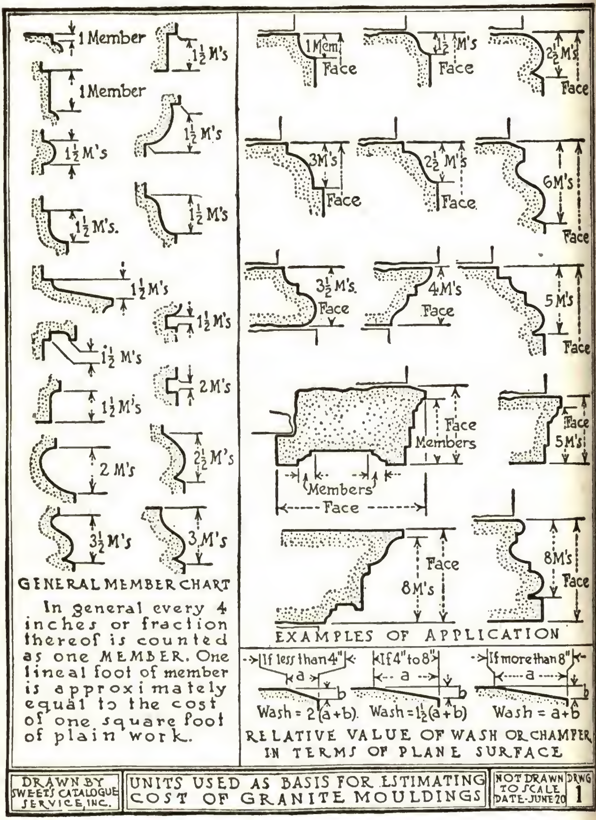

FIG. 8.—(*Courtesy National Building Quarries Association.*)

From Table 29, we estimate the setting time as follows:

Ashlar work, including sills, grade course, etc., 990 cubic feet.	
Mason @ 8 hours per 100 cubic feet	79.2
Laborers @ 48 hours per 100 cubic feet	475.2
Derrick @ 4 hours per 100 cubic feet	39.6
Ornamental work, 600 cubic feet.	
Mason @ 12 hours per 100 cubic feet	72
Laborers @ 36 hours per 100 cubic feet	216
Derrick 6 hours per 100 cubic feet	36
Cleaning and pointing, 1,800 square feet (from Table 31).	
Mason @ 4 hours per 100 square feet	72
Laborers @ 2 hours per 100 square feet	36
Pole scaffolding, laborers	15

Summary

Truck 17 hours @ $3.50			$ 59.50
Laborers, unloading, etc	127.2		
setting ashlar	475.2		
setting ornament	216		
cleaning, etc	36		
scaffold	15		
Total	869.4		
	say 870 hours @	0.70	609.00
Masons, setting ashlar	79.2		
setting ornament	72		
cleaning, etc	72		
Total	223.2		
	say 223 hours @	$1.50	334.50
Derrick on ashlar	39.6		
on ornament	36		
Total	75.6 hours		
	say 9½ days @	$20.00	190.00
			$1,193.00

which equals seventy-five cents per cubic foot.

Example 2.—To find the cost of setting the same job by hand, if conditions make that practicable, using a breast derrick and working from the floors as the building goes up, the method is as follows; Figure the trucking, loading and unloading as before.

It is necessary to figure now on the cost of the time needed to put the stones on the elevator, elevating them, and taking them off again and distributing them on the upper floors. Assuming 360 cubic feet of stone on the first story, we have 1,230 cubic feet to elevate to the upper stories and the distance to handle it will be taken as 100 linear feet, therefore, 1,230 cubic feet @ 3 hours per 100 equal 36.9 hours. The time required for setting, from Table 29, will be as follows:

	Masons' time	Laborers' time
270 cubic feet sills, lintels, grade course, etc.	81	81
720 cubic feet ashlar	86.4	144
600 cubic feet ornament	120	180
Totals	287.4	405

The cost of the cleaning, pointing and scaffolding will be as before.

SUMMARY

Trucking cost as before			$ 59.50
Laborers, unloading	127.2		
wheeling	36.9		
setting	405		
cleaning, etc.	36		
scaffold	15		
Total	620.1		
	say 620 hours @	0.70	434.00
Masons, setting	288		
cleaning, etc.	72		
Total	360 hours		
	@	$1.50	540.00
Elevator, from Table 27,			
360 cubic feet on first story	0		
400 cubic feet on second story	12		
830 cubic feet on third story	50		
Total	62 hours		
	say 8 days @	$20.00	160.00
			$1,193.50

In each of these examples the compensation insurance, moving of equipment to and from the job, general supervision, overhead costs and profit should be added in order to determine the correct price to charge for the work.

It is to be noted that, in this instance, the cost of hand setting and power derrick setting figure out to almost exactly the same amount so that, other considerations being equal, it would probably be advisable to set the stone with the hand derrick, rather than go to the trouble of bringing another derrick to the building, arranging for power if it were not practicable to use the same power as already in the building for the elevator, and then removing that equipment at the completion of the work.

This is not an invariable rule, yet it is not at all unusual for a job of this size, as the economy resulting from power equipment does not become effective until much larger quantities of stone are handled.

In *Engineering News-Record* of March 13, 1919, I described an instance where we completed some heavy repair work on a stone dam for less than $4,000 with a hand derrick, though the estimates of our competitors, who contemplated the use of power equipment, ran as high as $39,000.00

That was an exceptional instance. It happened during a period of coal shortage, the nearest railroad was over 2 miles away and the conditions and the site were such that the cost of installing a steam-engine would have been equal to the total cost of operating the hand-derrick.

CHAPTER V

FIREPROOFING AND FIREPROOF CONSTRUCTION

SECTION I. GENERAL

Fireproof construction, or more properly speaking fire-resistive construction, divides itself into three general types; terra-cotta, gypsum and concrete.

Brickwork is, of course, a form of fire-resistive construction, in fact, it is the best known form, and also the most effective form of terra-cotta fire-resistive construction.

Terra-cotta and gypsum constructions are largely used for walls, floors, partitions and roofs and are usually placed by masons.

Concrete fireproofing is, however, usually placed by laborers, and since the same general methods apply as for other forms of concrete work, it will be more fully discussed in Chapter VI.

Hollow-tile Fireproofing.—The term fireproofing, as here used, includes all those forms of hollow terra-cotta building material that are commonly used, such as, flat and segmental floor-arches, roof-arches, "book" tile, beam-, girder- and column-covering, wall and partition tile, furring tile.

In taking off quantities of tile required for any piece of work it is necessary to make some allowance for breakage in handling and in cutting to fit around openings, against jambs, etc. It is impossible to lay down any exact rules for figuring the breakage, it may vary all the way from 1 to 10 per cent but a good method is to allow 3 per cent breakage for areas having no openings, no deductions for openings under 10 square feet, one-half of openings from 10 to 21 square feet, deduct full opening, if over 21 square feet, and add enough tile to go once around the opening.

Practically all forms of hollow-tile fireproofing can be figured and bought by the square foot or by the piece. In buying by the piece, only one 12 by 12 tile is required, no matter what the thickness, per square foot but 1½ tiles, are required of the 8 by 12 size.

"Book" tile, which are used for roofs where no heavy loads are to be carried, and are so called because their "tongue and groove" cross-section makes them resemble large books, usually come in 12 by 24 size, so that each title will lay 2 square feet. They are placed upon a structural steel frame consisting of angles and tees, and therefore no form work or centering is required.

Furring tile usually come in the "split" form, *i.e.*, a block resembling a partition block which is scored in such a manner that it can readily be split into two halves, each of which is a furring tile.

Figuring Flat Arches.—When figuring flat or segmental arches for estimating purposes, it is sufficient to take from the plans the number of square feet to be covered but, when listing tile for shipment to the work, it is necessary to compute carefully the number of skewbacks, key blocks, voussoirs, soffit tile, girder shoes, etc., that will be required.

The literature issued by the manufacturers of terra-cotta fireproofing contains such a wealth of information on that subject that it is unnecessary to encumber these pages with a repetition of it.

However, it is essential that care should be taken to figure upon exactly the kinds of tile in each case that the specifications require; dense, porous or semi-porous, smooth-faced, scored, etc.

In earlier chapters we have discussed very thoroughly the cost of hauling and, knowing the weight of the various kinds of tiles likely to be used, it is a simple matter to determine the number that can be handled in a load.

The cost of loading and unloading is not so simple a matter, since there is such a variety of weights to be considered and since it is possible for a man to handle a tile weighing 30 pounds about as quickly as one weighing 20 pounds.

The following tables provide the necessary data for estimating loading and unloading costs, hauling, etc.

Split furring tile weigh the same per *block* as a partition block of twice the thickness.

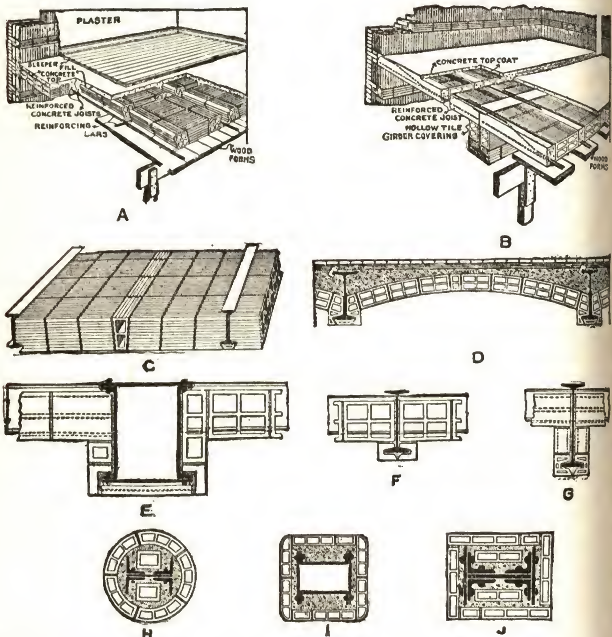

FIG. 9.—Terra-cotta fireproof construction. (*Courtesy National Fireproofing Company.*)

A, B, Combination hollow tile and concrete floor construction. C, End construction flat arch. D, Segmental arch. E, F, G, Beam and girder protection. H, Round column covering. I, J, Square column covering.

However, the weights given in the table are average or standard weights and may vary appreciably in different localities. Care should therefore be taken to determine whether these weights apply when buying fire proofing by weight.

The cost of building scaffolds for partition work can be determined on the basis of one scaffold builder for each

four masons; and for wall-furring, one scaffold builder for each three masons.

The cost of making and handling the mortar is, of course, the same as for the same grade of mortar when used for brickwork.

NOTE.—The best results in hollow-tile construction are obtained with a strong cement mortar to which enough lime-putty has been added to make it spread very freely. This works better than a lime and cement mortar made in the ordinary way.

TABLE 32.—WEIGHTS OF HOLLOW TILE

Thickness, inches	Load bearing wall tiles		Partitions		Book tile	
	Pounds per square foot	Square feet per ton	Pounds per square foot	Square feet per ton	Pounds per square foot	Square feet per ton
2	..	..	12	166	12	166
3	..	..	14	143	14	143
4	..	..	16	125	16	125
5	..	..	19	105		
6	29	68	22	91		
7	..	..	25	80		
8	34	59	30	66		
9	..	..	33	61		
10	40	50	35	57		
12	52	38	40	50		
	Segmental floor arches		End construction, flat arches		Side construction, flat arches	
6	27	74	..	..	27	74
8	33	61	27	74	29	68
9	..	..	31	64	36	55
10	..	..	33	61	39	51
12	..	..	38	53	44	45

TABLE 33.—LAYING HOLLOW TILES

(Hours of masons' time per 100 square feet[1])

Thickness, inches	Partitions	Furring	Segmental arches	Flat arches
2	4.0	3.0		
3	4.5	4.0		
4	4.5			
5	4.5			
6	5.0	...	3.0	4.0
7	5.0			
8	5.5	...	4.0	5.0
9	6.0			
10	6.5	...	...	6.0
12	7.0	...	...	7.0

NOTE.—Time for partitions, furring, and walls is based upon the use of tiles 12 × 12 × t, if tiles 8 × 8 × t are used, the time must be increased 25 per cent.

(Laborers' time)

Thickness, inches	First 40 feet of horizontal distance, stock pile to work	Each additional 40 feet	Time of elevator per story
2	1.70	0.40	0.05
3	1.70	0.40	0.05
4	1.75	0.45	0.10
5	1.80	0.50	0.15
6	1.85	0.55	0.20
7	1.90	0.60	0.25
8	1.95	0.65	0.30
9	2.00	0.70	0.35
10	2.10	0.75	0.40
12	2.25	0.85	0.50

[1] Add laborers' time, as given below, plus the cost of scaffolding as determined from page 73, also elevator time as indicated.

In figuring costs it is necessary to include scaffold-building, mortar making, tending, and, for floor systems, building forms or "centering" and removing forms.

Where metal strips, or other forms of ties are specified in partition work, add one hour of mason's time per 100 square feet.

Where nails must be driven into brick walls to act as anchors for furring add four hours of mason's time per 100 nails, which will usually be spaced about 25 nails to the 100 square feet of furring.

In some localities it is practicable to have the laborers set the soffit tiles under the beams when putting up the forms but bricklayers are inclined to object to the practice.

NOTE.—Where "lip" skewbacks are not used, one soffit tile will be required for each linear foot of steel beams.

Where the girders are to be fireproofed it will usually require two shoe tiles, or girder tiles, and one soffit tile for each linear foot of girder.

Beside that, when the girders extend more than three inches below the bottoms of the beams, it will be necessary to figure upon sufficient partition tile, or hollow bricks to fill the space between the top of the shoe tile and the under side of the floor construction.

TABLE 34.—LAYING HOLLOW TILE SPECIALTIES
(Hours of masons' time)

Thickness, inches	Per 100 square feet		Per 100 linear feet	
	Round column	Square column	Soffit tile	Shoe tile
2	2.0	2.5		
3	2.5	3.0		
4	3.0	3.5		
. .	. . .	. . .	1.5	1.5

NOTE.—Add laborers' time and hoisting time as before.

TABLE 35.—CENTERING FOR HOLLOW TILE ARCHES
(Per 100 square feet)

	Segmental arches	Flat arches		Add for raised skews
		Center hung	Side hung	
FBM timber..	80	100	80	20
FBM plank...	80	210	210	
FBM boards..	145			
Hours, laborers.........	5	5	4.5	0.5
Hours, carpenters.........	2.5			

NOTE.—Laborers' time includes removal of forms. When forms can be reused, material and carpenters' time need be figured only once.

TABLE 36.—MORTAR REQUIRED
(Cubic yards per 100 square feet)

Inches	Furring	Partitions, column covering, book tile	Floor construction
2	0.07	0.10	
3	0.09	0.12	
4	....	0.14	
5	....	0.15	
6	....	0.17	0.17
7	....	0.20	0.20
8	....	0.23	0.23
9	....	0.26	0.26
10	....	0.29	0.29
11	....	0.33	0.33
12	....	0.36	0.36

This table is figured upon the basis of an average thickness of joints of ½ inch. It would be possible to construct

a table giving the amount of mortar for any thickness of joints but, since the edges of the tiles are seldom straight, it is not practicable to maintain an exactly even joint and this table is, therefore, as nearly correct as working conditions warrant.

Load-bearing tiles are used for outside wall construction as well as bearing partition construction, to take the place of brickwork. They are usually faced on the outside by

TABLE 37.—LOAD BEARING TILE

Size	Weight per square foot	Hours of masons' time per 100 square feet	Cubic yards mortar per 100 square feet
6 by 12 by 12	29	6	0.26
8 by 12 by 12	34	7	0.30
10 by 12 by 12	40	7.5	0.38
12 by 12 by 12	52	8	0.45

TABLE 38.—INTERLOCKING WALL TILE[1]

Thickness	Quantities per 100 square feet of wall			
	Tiles	Bonding tiles	Cubic yards mortar	Hours masons' time
8-inch tile wall........	210	..	0.30	9
8-inch backing to brick wall................	180	..	0.25	8.5
12-inch tile wall........	320	..	0.45	14
16-inch tile wall........	400	70	0.63	21
21-inch tile wall........	530	..	0.75	24

[1] (Weight of 1 tile = 17 pounds. Corner tiles, 2 required for each linear foot of corner. Jamb tiles, 1 required for each linear foot of jamb. Bonding tiles, 0.7 piece for each square foot of 16-inch wall.)

stucco but sometimes smooth-faced blocks are used that require no other finish.

The cost of handling these tiles, except mason's time in laying, may be calculated from Table 38 by increasing the times given for partitions by ten per cent.

Interlocking tiles, of the Denison patented type, have come into very general use and are now made by licensees in many parts of the country. These licensees are glad to furnish much more detailed information as to the use of interlocking tiles than is given here but Table 33 gives all of the necessary information for figuring the cost of handling and laying.

For each linear foot of jambs or corners, add 0.10 hour masons' time.

Figure cost of handling, unloading, etc., in the same manner as for an equal number of 4-inch partition blocks.

NOTE.—The time for foremen on all hollow-tile work should be figured by the method previously indicated in connection with brickwork.

SECTION II. FORMS OR CENTERING

In fireproofing the term "centering" is probably in more general use than is the term "forms," though both have practically the same meaning.

However, for hollow-tile floor arches, of all types, it is most usual to use forms which are merely assembled from 2-inch scaffold-planks and "stringers," hung from the steel floor framing by means of adjustable wrought-iron hangers. The work is usually done by laborers.

For combination hollow-tile and concrete construction, it is usual to build up the form of planking which, because of the longer spans used, must be supported at regular intervals by "shores" or posts. The work may be done either by carpenters or handy laborers.

For reinforced concrete or cast-in-place gypsum construction, it is usual to build a tightly constructed form of

boards, supported by joists, posts, or other members as may be necessary. This work is almost invariably done by carpenters.

Centering for Hollow-tile Arches.—Centering for flat-arches is a very simple form of construction, particularly where the ceiling surface is kept level and carried on the line formed by the under surface of the skewbacks.

Stringers, usually built of two pieces of 2 by 6 timber, separated by 1-inch blocking at fairly close intervals are usually used though some builders use single stringers.

The stringers are hung from the beams by wrought iron hangers, ¾-inch round rods being used, which are fitted with clips to attach to the upper flanges of the beams. Adjustment in length of the hangers is provided by a screw thread and nut at the top.

Scaffold planks are then laid across the stringers to form the surface upon which the tiles are laid and which supports the tiles until the mortar in the joints has set and the arches become self-supporting.

When the specifications require that the arches must be cambered (usually the amount will not exceed ½ inch), additional stringers must be provided over the tops of the beams and the lower hangers supported at the center of the span. Then the skewbacks or soffit tiles can be set at the beams, and the hangers drawn up in the middle so as to give the required camber. This is termed "center-hung centering."

Centering for segmental arches is made as for flat arches but, in addition, arch forms consisting of segmental ribs, cut to proper cross-section, and covered with 1-inch strips, are placed on top of the planking in order to give the curved shape to the arch.

As it is customary in steel-framed buildings to keep the spans between beams as uniform as possible, very little cutting of the lumber is necessary and it should be possible to use all of the lumber over at least four times.

The figures in the table are the amount of lumber needed for one time, the cost of the material actually used will

be found by dividing the quantity given by the number of times it can actually be used.

This number cannot be determined without knowing the conditions under which the work is to be done.

For instance, in building a four-story building and pushing the work with any speed at all, the builder would probably put in enough forms for the first and second floors. Then the first floor forms would be re-used on the third floor and roof, the second floor forms would be re-used on the fourth floor. This is an average use of 2½ times.

If he had no further use for them as centering, he could then credit the planks to the job at their depreciated value as second-hand scaffold-planks and the stringers as so much wood.

On the other hand, if he were constantly installing hollow-tile arches, the stringers should have a very long life, and the depreciation chargeable to any particular contract would be very small.

The hangers should last indefinitely, so it is entirely a matter of judgment as to what proportion of their cost should be charged to any job.

When using Table 35 it is necessary first to figure the cost of getting the lumber to the site of the work, unless it is bought delivered on the job.

The time given for carpenters is that required for cutting out the arch-ribs and attaching the "lagging."

SECTION III. GYPSUM FIREPROOFING

In general, the laying of pre-cast gypsum fireproofing, such as solid or hollow partitions, furring, etc., is an operation very similar to the laying of corresponding shapes of terra-cotta hollow-tile, but the work will ordinarily proceed much more rapidly because the nature of the material, as well as its lighter weight makes practicable the use of much larger units and the partition tiles are usually made 12 by 30 inches, so that 2½ square feet of partition can be laid at one operation.

Another reason why faster work can be done with gypsum fireproofing is the much more regular shape of the units.

Being cast, and not burned, gypsum partitions are not subject to any shrinking or warping that will draw them from their intended shapes.

Greater Speed with Gypsum.—Because of the greater speed of laying, more scaffold men will be required to keep the same number of bricklayers busy than would be the case with hollow tile and an average of one scaffold builder for each mason is a fair basis for figuring.

The cost of handling gypsum partitions may be figured on the basis of Table 39.

The cost of laying and the amount of mortar required can be determined directly from the proper columns of Tables 39 and 40 but it should be remembered that either "patent plaster" or "prepared mortar" are used with gypsum partitions. Portland cement mortar will not properly bond gypsum construction.

Table 40 gives the quantities of materials needed to produce a cubic yard of mortar and the cost of mixing this mortar may be figured as explained in the discussion of brickwork.

TABLE 39.—GYPSUM FIREPROOF PARTITIONS

Thickness, inches	Weight per square foot	Square feet per ton	Hours masons' time per 100 square feet	Cubic yard mortar per 100 square feet
2 solid	9	222	3.0	0.04
3 hollow	10	200	3.0	0.05
3 solid	13	154	3.5	0.05
4 hollow	13	154	3.5	0.07
5 hollow	16	125	4.0	0.09
6 hollow	18	111	4.5	0.10
8 hollow	24	83	5.5	0.14

NOTE.—Figure scaffolding as for brickwork. Figure laborers' time and elevating time at 0.80 time given for plain hollow tile of equal thickness.

TABLE 40.—MORTAR FOR GYPSUM PARTITIONS

Proportions	Material per cubic yard mortar	
	Tons patent mortar	Cubic yard sand
1:2	0.65	0.94
1:2½	0.58	0.96
1:3	0.50	1.00

SECTION IV. COMBINATION HOLLOW TILE AND CONCRETE

Floor Construction.—Because the number of different types or "systems" of combination hollow-tile and concrete floor constructions is very great and because some of them are covered by patents and can only be installed by licensees under such patents, no attempt will be made to make this discussion cover every form of construction in general use. Only the "standard" types can be covered here but the same principles can be used for any other system when the details of it are known.

Such books as "Concrete Engineers' Handbook," by Hool and Johnson (McGraw-Hill Book Company, Inc.), "Useful Data," (Corrugated Bar Co., Kalman Steel Co., Successors) and the literature issued by National Firepoofing Co. and other manufacturers of hollow tile, contain all of the information needed by the engineer who would determine the requisite thickness of the tiles, thickness of top-course and amount of reinforcing steel.

In Chapter VI we shall discuss the methods to be used in estimating the costs of the materials needed to make concrete of given proportions, as well as the cost of mixing that concrete and placing concrete under most of the

conditions likely to be encountered in ordinary building construction.

The same principles are to be used in estimating the cost of the concrete used in combination hollow-tile and concrete construction and the quantity of concrete can readily be determined by reference to the specified requirements for thickness of tile and thickness of top-slab, if any.

Since tiles 12 inches wide, separated by a "rib" or "joist" 4 inches wide, is almost the universal type, it is evident that the joists are always 16 inches center to center and, therefore, each square foot of floor contains three-fourths the amount of concrete in one linear foot of "joist," plus the amount of concrete in a square foot of top-slab.

Thus, a construction of 6-inch tiles, with a 2-inch top-slab, will contain the following quantities in each 100 square feet of floor.

	Cubic Feet
75 6 by 12 by 12 tiles	
75 linear feet 6-in. × 4-in. joists........	12.5
Top-slab (2-in. × 12-in. × 12-in.) × 100...........................	16.7
	29.2 cubic feet = 1.08 cubic yards

Table 41 gives the concrete quantities for a variety of constructions (the tile quantity is always 75 where the width of joists is 4 inches) and the quantities for any other construction may be determined by following the method given above. In the table an allowance of 5 per cent has been made in the joists to provide for the additional concrete used at the ends of the rows of tile, over the supports.

The cost of getting the tiles into the building can be estimated from the information given in Tables 32 and 33.

Placing the tiles on the forms, which can almost always be done by laborers, is an item that must not be overlooked and can be calculated from Table 41.

TABLE 41.—COMBINATION HOLLOW TILE AND CONCRETE FLOORS

Construction	Cubic yards concrete per 100 square feet floor	Hours labor placing tiles per 100 square feet floor
4 plus 2..........	0.944	3
4 plus 2½........	1.104	3
5 plus 2..........	1.025	3
6 plus 2..........	1.106	3.5
8 plus 2..........	1.268	4
8 plus 2½........	1.428	4
10 plus 2..........	1.43	5
10 plus 2½........	1.59	5
10 plus 3..........	1.74	5
12 plus 2..........	1.592	5.5
12 plus 2½........	1.752	5.5
12 plus 3..........	1.902	5.5

NOTE.—Figure cost of placing concrete as indicated in Chapter VI. See Table 47 for two-way construction.

Figure cost of forms as indicated below.

Number of blocks for 12-inch wide tiles and 4-inch wide joists is always 75 per 100 square feet.

TABLE 42.—FORMS FOR COMBINATION TILE AND CONCRETE FLOORS

Thickness of tile, inches	Spacing of joists, inches	Spacing of posts, inches	FBM, Lumber per 100 square feet	Labor, hours per 100 square feet		
				Assemble and erect	Strip	Re-erect
4	58	72	280	4.2	1.1	3.1
5	56	66	286	4.3	1.1	3.2
6	56	66	286	4.3	1.1	3.2
8	52	60	292	4.4	1.2	3.3
10	50	54	300	4.5	1.2	3.4
12	48	48	310	4.7	1.2	3.5

Reinforcing Steel.—Because this form of construction is not ordinarily used for heavy live-loads, it is not customary to use complicated reinforcement.

The most common method is to use one or two bars in each rib, either or both of which may be bent up at supports. Where the rods are carried across a support, care must be taken to figure in the necessary added length of rod and its weight. Also the weight of transverse reinforcement, if any be used.

The weight of the steel may be calculated by counting the number of rods, then multiplying them by their length and weight per foot or the method indicated in Table 43.

Always add 5 per cent to the computed quantity of steel, in order to take care of waste due to cutting, bending, etc.

Because stirrups, and similar members, are not regularly used in hollow-tile and concrete constructions, the cost of forming and installing them will be fully covered in the next chapter, which takes up the entire subject of reinforced concrete work.

TABLE 43.—REINFORCING RODS

Nominal size inch	Weight per linear foot		Pounds per 100 square feet	
	Round bar	Square bar	One round bar per joist	One square bar per joist
½	0.67	0.85	51	64
⅝	1.05	1.35	79	102
¾	1.52	1.91	114	143
⅞	2.06	2.64	155	198
1	2.67	3.40	200	255
1⅛	3.41	4.30	256	322
1¼	4.20	5.35	315	403

Steel in Cut Lengths.—It is the custom to purchase the steel cut to scheduled lengths so the only costs that are incurred at the site are bending and placing.

This work can just as readily be done by any handy men, after a little training, but union regulations in many sections require reinforcing steel to be placed by structural steel erectors or metal-lathers.

Table 44 gives the production that may be expected from men of ordinary skill under good supervision.

TABLE 44.—REINFORCING STEEL
(Time in labor hours)

Bar sizes inch	Bending per 100 eighth or quarter bends	Placing 100 bars		
		Under 10 feet long	10 to 20 feet long	20 to 30 feet long
½ or under........	1	4.50	5.75	7
¾ and .⅞........	1.33	5.25	6.75	8.25
1.................	1.67	6.25	8	9.75
1¼ and 1⅛.......	2	7.50	9.75	11.50

Forms.—For a "one-way" type of floor construction, open forms, similar to those used for ordinary hollow-tile floor construction, except that supporting "shores" or posts will be required, will suffice. In fact, it is only necessary that the planks should be spaced so as to come under the "joists" or ribs and to extend a sufficient distance on either side to support the tiles.

For a "two-way" construction, however, unless some form of "channel tiles" are used, it will be necessary to construct a solid floor of form work, as for a straight reinforced concrete slab.

Except for the item of forms, the instruction given here for estimating "one-way" constructions will apply for "two-way" constructions, if proper allowance is made for the difference in quantities.

A good type of form construction consists of 2 by 8 planks, one under each "joist," resting on 4 by 6 joists, supported by 4 by 4 posts. There will also be the neces-

sary amount of bracing and bolsters and short planks, or pedestals, under the lower ends of the posts.

Table 45 gives the necessary information for determining the number of joists and posts required, and 25 per

TABLE 45.—FORM JOISTS AND POSTS

Type of construction	Spacing of joists in inches	Spacing of posts in inches
4 + 2	58	72
4 + 2½	58	72
5 + 2	56	66
5 + 2½	56	66
6 + 2	56	66
8 + 2	52	60
8 + 2½	52	60
10 + 2	50	54
10 + 2½	50	54
10 + 3	50	54
12 + 2	48	48
12 + 2½	48	48
12 + 3	48	48

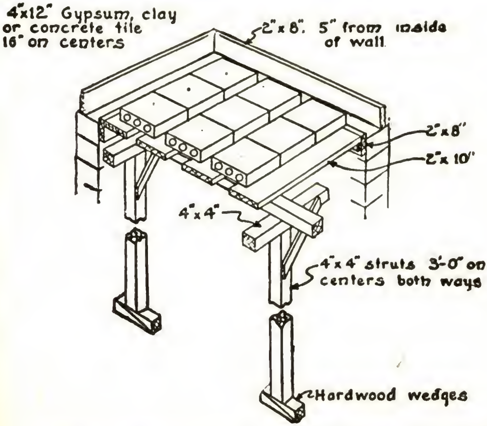

FIG. 10.—Forms for combination floors. (*Courtesy Portland Cement Association.*)

cent should be added to the quantity thus calculated in order to take care of the bracing, bolsters and pedestals.

Salvage values are to be determined, upon the same basis as that already outlined for centering for hollow-tile construction.

Example.—Thus, to support a floor construction consisting of 10-inch tile and 4-inch by 10-inch concrete joists with a 2½-inch top, over an area 25 by 100 feet, would necessitate the use of the following form lumber, the clear story height being assumed as 12 feet:

	FBM
Planks (25-foot length not being a stock length in most places, we must use a 14-foot and a 12-foot length).	
2 × 8: 75 pieces, 12 feet; 75 pieces, 14 feet	2,600
Joists (25 feet divided by 50 inches plus 1 joist) = 7 rows.	
4 × 6: 35 pieces, 20 feet long	1,400
Posts (7 rows joists, 100 feet long, 1 post each 54 inches, plus 1 post in each row) = 161 posts.	
4 × 4: 161 pieces, 12 feet long	2,576
Braces, etc. (25 per cent of joists and posts)	944
	7,520

which equals practically 3 FBM per square foot of floor construction.

The total time required for handling this material, after delivery to the site, may be calculated from Table 46. The time is given there in labor hours, to be divided by the estimator among carpenters and laborers as local conditions may require, but the work is not beyond the skill of good laborers.

TABLE 46.—LABOR ON FORMS

Assembling and erecting	15 hours per 1,000 FBM
Stripping	6 hours per 1,000 FBM
Re-erecting	11 hours per 1,000 FBM

TABLE 47.—TWO-WAY COMBINATION HOLLOW TILE AND CONCRETE FLOOR CONSTRUCTION

Type of construction	Cubic yards concrete per 100 square feet of floor	Hours labor placing tiles per 100 square feet of floor
4 plus 1½	0.92	2.2
4 plus 2	1.43	2.2
5 plus 0	0.74	2.4
5 plus 1	1.05	2.4
5 plus 2	1.36	2.4
6 plus 1	1.18	2.7
6 plus 2	1.50	2.7
6 plus 2½	1.66	2.7
7 plus 1	1.37	3.0
7 plus 2	1.68	3.0
8 plus 1	1.52	3.4
8 plus 2	1.83	3.4
9 plus 1	1.66	3.8
9 plus 2	1.99	3.8
10 plus 2	2.14	4.2
12 plus 2	2.30	4.6

NOTE.—For tiles $12 \times 12 \times d$, with concrete ribs 4 inches thick between, figure 56 tiles per 100 square feet.

Figure mixing and placing of concrete as previously explained. Figure forms as for one-way construction, adding 10 per cent to the amount of lumber and the labor time.

CHAPTER VI

PLAIN AND REINFORCED CONCRETE WORK

SECTION I. GENERAL

It was the intention in writing this text, in so far as it is practicable to do so, to make each of the chapters complete in itself. However, there is hardly an operation in general building construction that is so unique that much that may be said of another operation will not apply to it as well.

For this reason, it will often be necessary for a student to master several different chapters before he will become really proficient in estimating the class of work covered by any one of them.

For instance, while this present discussion of the method of estimating the cost of concrete work will be rather lengthy, the student must also thoroughly master the chapters on excavating, brickwork, and timber framing, if he would get the best results in this particular work.

It is well to adopt a uniform procedure when listing quantities for any kind of work, particularly so for concrete work.

The best method is to start at the beginning and list the different items in approximately the same order in which they will be constructed, thus: wall-footing, pier-footings, walls, piers, etc. Also to follow a regular system of setting down the dimensions, *viz.*, length first, width or thickness second, and height third.

This method will always make it practicable to know just what each figure means and will also facilitate the calculation of form quantities.

Formwork Important.—It hardly seems necessary, at this late date in concrete construction, to stress the impor-

tance of carefully figuring all formwork, either by the number of square feet of contact area or by the number of board feet of lumber to be used, and not by lumping the cost of formwork into the cost of a cubic yard of concrete.

As a general rule the contact area method is used because it gives very close results and is sufficiently accurate for all ordinary kinds of construction. For unusual work that would involve difficult, extra strong or intricate formwork, the design of the forms should be worked out before estimating and the cost carefully computed on the basis of the material to be used and the work to be done.

Quantities of Materials.—Calculation of the quantities of materials required to produce a cubic yard of concrete has now been reduced to the simple operation of referring to a table. Numerous such tables in many varying forms, have been published, but the one which appears below is sufficiently complete for all ordinary uses. Most of the cement companies publish similar tables in handy pocket "calculator" form and are glad to furnish them without cost to people having need of them.

This is about as wide a range of proportions as is found in ordinary building work, except cement finish work, which is covered in a later section but in reinforced concrete work it is often necessary to use much richer mixtures in columns or other places where great compressive strength is required.

Portland cement is generally sold by the barrel, practically 3.8 cubic feet, and it is usually delivered in paper sacks holding one-quarter barrel each. Delivery is sometimes made in cloth bags of the same size, less frequently in wooden barrels, and occasionally in bulk car-loads.

Sand, gravel and crushed stone may be sold either by the cubic yard or by the ton. Since the quantity of material to be used will be figured on the cubic yard basis, prices per ton should always be converted to prices per cubic yard.

It is always advisable to obtain the correct weight per cubic yard of any material which is proposed to use, but

in the absence of more definite information the following weights may be used.

TABLE 48.—WEIGHTS OF CONCRETE MATERIALS

	Cubic yards per ton	Pounds per cubic yard
Sand	0.74	2,700
Gravel	0.74	2,700
¾-inch crushed trap rock	0.77	2,600
1½-inch crushed trap rock	0.785	2,550
1½-inch crushed limestone	0.85	2,360
¾-inch crushed granite	0.80	2,500
1½-inch crushed granite	0.832	2,400
Crushed slag	1.0	2,000

When figuring upon slag-concrete, as a substitute for stone- or gravel-concrete, it is necessary to keep in mind the fact that you will probably need at least one-fourth more mortar in your mixture than you would to get a concrete of the same consistency with stone or gravel.

SECTION II. HAULING AND HANDLING MATERIALS

Whenever possible, it is well to get prices on all materials delivered directly to the site of the work. However, this is not always possible and the information given here, as well as that contained in the chapter on excavating, will enable an estimator to figure his own delivery costs.

Loading and Unloading Time.—Thus, with three men working, a load of 15 barrels (60 bags) will require the wagon to stand for 20 minutes if loaded from the car and 25 minutes if loaded from the shed. If the force is larger, the time will be reduced proportionately.

Unloading will require ¾ minute of laborer's time per bag if placed on a pile and 1¼ minutes if placed in the shed.

In figuring the cost of cement do not forget to make allowance for the bags. Cloth bags are usually charged at 10 cents each and credited at the same price when returned,

TABLE 49.—QUANTITIES OF MATERIALS REQUIRED FOR VARIOUS MIXTURES OF MORTAR AND CONCRETE
(*Courtesy Ransome Concrete Machinery Co.*)

Mixture	Materials for one-bag batch			Resulting volume in cubic-feet		Quantities of cement, sand, and pebbles or stone required for 1 cubic yard of compacted mortar or concrete				
	Cement in sacks	Sand, cubic feet	Pebbles or stone, cubic feet	Mortar	Concrete	Cement in sacks	Sand		Stone or pebbles	
							Cubic feet	Cubic yard	Cubic feet	Cubic yard
1 :1½	1	1.5	...	1.75	...	15.5	23.2	0.86		
1 :2	1	2.0	...	2.1	...	12.8	25.6	0.95		
1 :2½	1	2.5	...	2.5	...	11.0	27.5	1.02		
1 :3	1	3.0	...	2.8	...	9.6	28.8	1.07		
1:2 :3	1	2.0	3.0	...	3.9	7.0	14.0	0.52	21.0	0.78
1:2 :4	1	2.0	4.0	...	4.5	6.0	12.0	0.44	24.0	0.89
1:2½:4	1	2.5	4.0	...	4.8	5.6	14.0	0.52	22.4	0.83
1:2½:5	1	2.5	5.0	...	5.4	5.0	12.5	0.46	25.0	0.92
1:3 :6	1	3.0	6.0	...	6.4	4.2	12.6	0.47	25.2	0.94

charges prepaid, in good condition to the cement company's mill.

Since there is no way of knowing in advance how many bags will be lost or damaged on the work, it is good practice to figure on a loss of one bag out of each four; this figure also to take care of the cost of return freight and handling charges. Paper bags or wooden barrels are not returnable for credit.

When sand or gravel must be obtained directly from the bank, the cost of obtaining it can be figured as explained in the chapter on excavating and due allowance must be made for the cost of stripping off loam or other worthless material.

The bank should be visited and as careful a computation as is practicable under the circumstances should be made of the quantity of material to be stripped off and this cost divided over the cost of the quantity of usable materials required from the bank.

It will seldom be practicable to use a "bank-run" mixture of sand and gravel in concrete, but will usually be necessary to screen it to separate sand and gravel. Where it is practicable to set up the hand-screen at the bank, an allowance of 35 minutes of laborer's time will be sufficient for each cubic yard of the bank-run material.

The proportion of sand and gravel that any bank will produce can only be determined by test, and such a test should always be made when estimating on important work.

A word of caution may be added here. Quite frequently a bank of sand may be entirely suitable for concrete as far as may be determined by visual examination, yet a chemical analysis or a test of a sample of concrete made from the sand may disclose the presence of vegetable acids or other impurities that would make the sand unsafe for use. It is well to investigate this feature thoroughly when estimating.

Aggregate in Carloads.—When sand, gravel or broken stone is purchased in carload quantities the following figures will govern: Cost of carting from car to the work must be figured as previously explained and added to these costs.

These figures are also to be used in computing the cost of moving material from a sand or gravel bank to the work.

Figures are given in hours of labor time, the waiting time of the vehicle will be determined by its capacity and the number of men employed in loading. The waste time of the men will be determined by the number of wagons or trucks employed and their headway interval.

TABLE 50.—LOADING MATERIALS PER CUBIC YARD
(Time in labor hours)

	From ground to wagon		From gondola car to wagon	
	Wet	Dry	Wet	Dry
Sand	0.50	0.34	0.45	0.3
Gravel	0.65	0.47	0.60	0.4
Crushed trap-rock	....	0.51	....	0.44
Crushed granite	....	0.49	....	0.42

Lost time of men and wagons may be reduced to a minimum by the use of unloading boxes, which are hung on the side of the car and into which the material is shovelled. When a wagon is to be loaded it is driven under the box, the contents dumped into the wagon, the wagon driven away and the box made ready to receive the load for the next wagon.

The student who desires to pursue the study of mechanical methods of handling concrete materials will find much valuable and interesting material in Gillette's "Handbook of Construction Cost."

SECTION III. MIXING AND PLACING

Now-a-days, very little concrete in building work is mixed by hand, the usual practice being to use a gasoline machine-driven mixer. Steam mixers have been used in some cases but they have come into disfavor because of the need of having a skilled man—in many States he must be licensed—to take charge of the boiler and engine.

Electric motor-driven mixers are also used at times, but they have not attained any great vogue.

Whether the mixing be done by machine or by hand, it must be remembered that the number of yards of material fed into the mixer or onto the board will always greatly exceed the number of yards of concrete taken out.

For instance, 1-3-6 mixture, using 2½-inch stone and under with the dust screened out, will require for each cubic yard of concrete:

	0.94 cubic yard stone
	0.47 cubic yard sand
	0.15 cubic yard cement
Total...	1.50 cubic yards material

which is the quantity that must be handled from stock-pile or cement-shed to the mixer.

Since this is dry material, the following figures may be used: One laborer can handle and move any of the following quantities of materials a distance of 40 feet in 1 hour:

1.65 cubic yards sand or gravel
1.71 cubic yards crushed traprock
1.93 cubic yards crushed limestone
1.78 cubic yards crushed granite
2.22 cubic yards crushed slag
40 bags portland cement

When the mixing is by machine, it is necessary to know the capacity of the mixer in cubic yards per hour for average running and the daily charge or rental rate of the mixer, as well as its consumption of fuel per day or hour.

Sometimes the capacity of a mixer is limited by a clause in the specifications which requires that the concrete be mixed for a given number of minutes before discharging, but usually the time of the mixer is determined by the ability of the machine to deliver well-mixed product.

There are many records quoted ranging from a batch a minute upward, but it is hardly safe to figure on better than an average of 15 batches per hour for the usual run of concrete work in building.

Thus, if the mixer is a "one-bag" size it will turn out 15 batches of 6.42 cubic feet of mixed concrete each (10 cubic feet in-put each) when working on a 1-3-6 mixture, using 2½-inches-and-under stone with dust screened out. This equals 3.57 cubic yards of concrete.

From the mixer, the laborers can each receive an average of 35 cubic feet per hour and wheel it a distance of 40 feet and dump it into the forms.

In addition to the number of men required to put the materials into the mixer and take the concrete away, allowance must be made for one man to tend the mixer, untie cement bags, etc., and at least one man to puddle the concrete into the forms.

With each increase of one bag in the nominal capacity of the mixer, one additional man will be needed for puddling and helping to dump concrete and one extra man to assist around the mixer.

All of these statements apply to average conditions. When estimating careful attention must be given to all details to determine whether less favorable or more favorable conditions are likely to be encountered.

If the actual mixing is to be done by hand an allowance of 1.25 hours labor time must be included for each cubic yard of concrete. This covers the cost of doing the work that is done in the mixer and also the work done by the men tending the mixer.

To all of the above figures must be added the cost of a foreman and a water boy. Their cost per cubic yard is found by determining the average production of the plant contemplated for the job under consideration.

Cost of Water.—The cost of water for mixing, while a small item, must always be included in the estimate, as well as the cost of connecting with the supply. Some cities make a flat charge per cubic yard of concrete, others require that the supply be metered and payment made accordingly. About 26 gallons of water are required for mixing a yard of concrete but, including wastes, water used for sprinkling and other purposes, the actual quan-

tity used on the job will be more nearly 100 gallons per cubic yard.

After the concrete has set and the forms are removed, it is usually necessary to smooth all exposed surfaces, erase form-board marks, and fill up hollow spots. Since the cost of doing this work is entirely dependent upon the care in building the forms and placing the concrete, it is a very difficult matter to determine the cost of finishing in advance.

However, the following figures may be used for all ordinary work:

TABLE 51.—MIXING AND PLACING CONCRETE
(Man hours per cubic yards)

Average distance to move materials, feet	Charging mixer	Mixing and delivering	Elevate[1]	Spread or puddle
25	1.30	1.50	0.15	0.25
50	1.45	1.80	0.30	0.25
75	1.60	2.10	0.45	0.25
100	1.75	2.40	0.60	0.25

[1] Figure this item at total unit cost per hour of operator plus hoist or elevator.

To determine cost per yard of mixing and placing concrete, take average distance from stock piles to mixer times rate given, horizontal distance from mixer to place of deposit times rate given, distance to be elevated times rate given, and time given for spreading or puddling.

To the cost thus determined at the rates of wage prevailing, add the cost of finishing operations as determined by the following tables:

TABLE 52.—FINISHING CONCRETE SURFACES
(Man hours per 100 square feet)

	Laborers	Masons
Cement wash	5	
Bush-hammer	..	20
Crandalling	..	20
Picking	17	
Carborundum rubbing	15	

Nothing has been said thus far about the cost of building runs for wheeling concrete. For ordinary plank runs the figures already given for moving concrete will be found large enough to take care of the usual amount of placing and moving.

Where the nature of the work is such that it will be necessary to build trestles or other special forms of runs, they must be figured separately, as will be explained in the chapter on timber-framing and the section on reinforced concrete construction.

Delivery and Removal of Equipment.—Allowance must also be made for the cost of delivering equipment to the work and removing it at the completion. This is so variable a factor that it is difficult to give any rules for estimating. For instance, a small gasoline mixer may be so compact as to require practically no setting up after unloading from the car or truck, while a large steam mixer may require several days' labor in order to put it in running condition.

Cost of freighting equipment to and from the location of the work can be ascertained by inquiry of the carrier, and charges for unloading from car to truck and truck to car, or vice versa, will average about 60 labor-hours per carload.

Since the equipment must be loaded and unloaded on both trips and must be freighted back to headquarters, a fair-sized job will have to bear the expense of 240 hours' loading and unloading labor, trucking costs at both ends, both times, and freight two ways.

When cement is to be stored at the work, sheds must be built for this purpose and, having determined the size necessary on the basis of the maximum amount to be stored, the cost of the shed can be estimated in accordance with the methods outlined in the chapters on carpenter work. Credit can, of course, be taken for the salvage value of the lumber after the shed is no longer required.

TABLE 53.—MATERIALS REQUIRED PER CUBIC YARD OF CONCRETE

(When specified according to cement-water-ratio method of strength control)

Designed 28-day strength in pounds per square inch	Bags of cement, using aggregate having maximum size of				
	¾ inch	1 inch	1½ inch	2 inch	2½ inch
3- to 4-inch slump:					
1,500	4.7	4.2	4.0	3.6	3.4
2,000	5.8	5.2	4.8	4.4	4.1
2,500	7.1	6.3	5.8	5.4	4.9
3,000	8.4	7.5	7.1	6.8	6.3
3,500	10.8	9.7	9.0	8.4	8.0
4,000	13.5	12.3	11.3	10.5	9.7
5- to 8-inch slump:					
1,500	5.7	5.2	4.7	4.4	4.0
2,000	7.3	6.8	6.3	5.8	5.2
2,500	9.0	8.4	7.9	7.1	6.4
3,000	11.2	10.4	9.7	9.0	8.4
3,500	14.4	13.5	12.3	11.3	10.4
4,000	20.1	18.0	16.9	15.9	15.0
Tons of washed sand required for any strength or slump	0.39	0.50	0.53	0.54	0.61
Tons of coarse aggregate:					
if gravel	1.13	1.14	1.15	1.16	1.17
if trap rock	1.11	1.12	1.13	1.15	1.16

If aggregates are purchased by the cubic yard on the ordinary basis of damp and loose measurement, the following figures should be used:

Sand, cubic yards	0.41	0.52	0.54	0.56	0.63
Gravel, cubic yards	0.99	1.00	1.00	1.01	1.01

TABLE 54.—STRENGTH OF CONCRETE

(As given by Prof. Duff A. Abrams. As affected by quantity of mixing water)

Maximum Number of Gallons per Bag	Compressive Strength in Pounds per Square Inch at 28 Days
7 to 7½	2,000
6¼ to 6¾	2,500
5½ to 6	3,000
5¾ to 5¼	3,500

(As affected by use of 2 to 4 per cent calcium chloride in mixture)

Age of concrete	2 days	7 days	28 days	3 months	1 year	3 years
Percentage of normal......	170	125	110	112	117	118

TABLE 55.—STRENGTH OF CONCRETE

(As given in District of Columbia regulations)

Proportions			Maximum slump permitted, inches	Assumed ultimate strength at 28 days, pounds
Cement	Fine aggregate	Coarse aggregate		
1	2	4	6½	2,000
1	1½	3	8½	2,000
1	1½	3	6½	2,500
1	1	2½	8½	2,500
1	1	2½	6½	3,000
1	1	1½	8½	3,000

SECTION IV. FORM WORK

Practically all forms for concrete work in buildings are now constructed of 1-inch boards, supported by 2 by 4 studs spaced from 12 to 24 inches apart, depending upon the height to be supported on the load to be retained. Sometimes 1½- or 2-inch plank may be used for particularly heavy work or when so specified by the architect or engineer.

Since the usual method is to use 1-inch boards, we will base our present estimates accordingly and the materials for 100 square feet of forms will be figured as follows:

	Square Feet	
Actual area of form......	100	
Waste for cutting, etc....	15	
	115 of	
1-inch boards or 115 feet B.M. @ $27 per 1,000........		$3.11
Studs 10 pieces 2 × 4 × 10–0.......	67 FBM	
Allowance for waste 15 per cent......	11 FBM	
	78 FBM	
78 FBM studs @ $36 per 1,000.......................		2.81
Nails (approximately 40 pounds per 1,000 FBM), 8 pounds @ 5 cents..................................		.40
Tie-wire (approximately 25 pounds per 1,000 FBM), 5 pounds @ 6 cents..................................		.30
First cost of materials for 100 square feet.............		$6.62

The cost of labor will be governed largely by the class of men employed. For instance, if local conditions make it necessary to have practically all of the work done by carpenters, the cost will naturally be higher than where a large part of it may be done by "handy-men."

On an ordinary job, where the laborers do all the handling of the lumber except the cutting, assembling and nailing in the building of the forms and also assist in the erection, each 100 square feet of forms, allowing an average of two FBM of material per square foot, will require the following:

TABLE 56.—LABOR PER 100 SQUARE FEET FORMS

	Assembling	Erecting	Total
Footings:			
Carpenters' time	2½	½	3
Laborers' time	1	1	2
Foundation walls: (first 10 feet in height)			
Carpenters' time	3	1½	4½
Laborers' time	1½	1½	3
Each additional ten feet in height			
Additional carpenters' time	...	½	½
Additional laborers' time	...	1	1
Piers (plumb sides):			
Carpenters' time	4	1½	5½
Laborers' time	1½	1½	3
Piers (pyramidal types):			
Carpenters' time	5	1½	6½
Laborers' time	1½	1½	3
Steps, lintels, etc.:			
Carpenters' time	7	2	9
Laborers' time	1½	2	3½
Slabs, platforms, etc.:			
Carpenters' time	6	1½	7½
Laborers' time	1½	1½	3

All of these figures are based on the assumption that the lumber will not be moved over 200 feet from stock-pile to its position in use. For greater travel add ½ hour laborers' time per 100 square feet for each additional 100 feet of travel.

After the concrete is hardened, the forms must be stripped and cleaned if they are to be re-used, or removed if they are of no further use.

For stripping, an allowance of 3 hours laborers' time per 100 square feet must be made.

When estimating the cost of forms, for any concrete work, it is necessary to determine how many times the forms may be re-used, if at all, and what value, if any, will be left in the form lumber at the end of the work.

Re-use of Concrete Forms.—If the forms can be re-used, as when there are a number of members of the same dimensions, without any rebuilding, it is only necessary to figure the cost of material and of building the first time, and

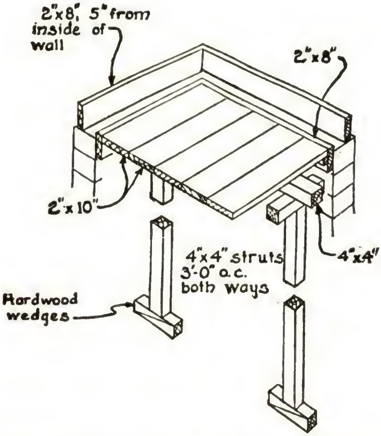

FIG. 11.—Forms for solid concrete floors. (*Courtesy Portland Cement Association.*)

then to add the cost of stripping and re-erecting as many times as the forms will be re-used.

If the forms are used only once, the lumber may have a salvage value of as high as one-third of its original cost, depending upon how much cutting up has been done, but when the forms are used more than once it is not wise to figure upon much re-sale value unless you have a certain place to dispose of the lumber.

Where the forms may be used again, but only after re-cutting and re-assembling, it is not necessary to figure for new lumber again, but a new allowance of at least 15 per

cent for waste must be made and an allowance of ½ hour carpenters' time per 100 square feet must be made to compensate for the slower work on the used lumber.

A further discussion of the cost of forms and form-building will be given in the section on reinforced concrete construction.

SECTION V. SIDEWALKS, FLOORS, ETC.

We have already discussed how to estimate the cost of handling the materials for concrete and of mixing the concrete and delivering it to the point at which it is placed in the forms.

The same principles govern the estimating of the cost of sidewalks, floors, etc., though it is usually easier to take off the quantities of sidewalks and floors by square feet, and of base, curbing, etc., by linear feet.

The following table, originally published by the author in *Concrete* for November, 1921, will facilitate the quick computation of the quantities of materials required for any floor or sidewalk job.

TABLE 57.—QUANTITIES OF MATERIALS REQUIRED PER 100 SQUARE FEET OF FLOORS, SIDEWALKS, SLABS, ETC.

(Quantity of cement is given in barrels, aggregate in cubic yards)

		Base course			
		1-2-4 mix	1-2-5 mix	1-2½-6 mix	1-3-6 mix
1 inch thick	cement	0.45	0.39	0.37	0.31
	sand	0.14	0.12	0.14	0.14
	aggregate	0.28	0.30	0.28	0.28
2 inches thick	cement	0.90	0.79	0.74	0.63
	sand	0.27	0.24	0.28	0.28
	aggregate	0.55	0.60	0.56	0.56
3 inches thick	cement	1.35	1.18	1.10	0.95
	sand	0.41	0.36	0.43	0.43
	aggregate	0.83	0.90	0.85	0.85
4 inches thick	cement	1.80	1.57	1.47	1.26
	sand	0.54	0.48	0.57	0.57
	aggregate	1.10	1.20	1.13	1.13
5 inches thick	cement	2.25	1.96	1.84	1.26
	sand	0.68	0.61	0.71	0.71
	aggregate	1.37	1.50	1.40	1.41
6 inches thick	cement	2.70	2.35	2.20	1.89
	sand	0.82	0.73	0.86	0.85
	aggregate	1.65	1.80	1.69	1.70
7 inches thick	cement	3.15	2.74	2.57	2.40
	sand	0.96	0.85	1.00	0.99
	aggregate	1.93	2.10	1.97	1.98
8 inches thick	cement	3.60	3.13	2.94	2.51
	sand	1.09	0.97	1.14	1.14
	aggregate	2.20	2.40	2.26	2.27
9 inches thick	cement	4.05	3.52	3.30	2.83
	sand	1.23	1.08	1.27	1.28
	aggregate	2.47	2.70	2.54	2.55
10 inches thick	cement	4.50	3.92	3.66	3.14
	sand	1.37	1.21	1.41	1.58
	aggregate	2.75	3.00	2.81	2.82
11 inches thick	cement	4.95	4.31	4.03	3.45
	sand	1.50	1.33	1.55	1.56
	aggregate	3.03	3.30	3.09	3.12
12 inches thick	cement	5.40	4.70	4.40	3.77
	sand	1.63	1.45	1.69	1.70
	aggregate	3.30	3.59	3.37	3.40

TABLE 57.—QUANTITIES OF MATERIALS REQUIRED PER 100 SQUARE FEET OF FLOORS, SIDEWALKS, SLABS, ETC.—(*Continued*)

(Quantity of cement is given in barrels, aggregate in cubic yards)

		Top course			
		1–1 mix	1–1½ mix	1–2 mix	1–2½ mix
½ inch thick	cement	0.75	0.59	0.50	0.43
	sand	0.12	0.14	0.15	0.16
¾ inch thick	cement	1.12	0.89	0.75	0.64
	sand	0.18	0.21	0.23	0.42
1 inch thick	cement	1.50	1.19	0.99	0.85
	sand	0.23	0.27	0.30	0.32
1½ inch thick	cement	2.25	1.78	1.49	1.27
	sand	0.34	0.41	0.45	0.48
2 inches thick	cement	3.00	2.37	1.98	1.69
	sand	0.45	0.53	0.59	0.63

		1–3 mix	1–1–1 mix	1–1–2 mix
½ inch thick	cement	0.37	0.50	0.41
	sand	0.17	0.08	0.06
	aggregate	....	0.08	0.13
¾ inch thick	cement	0.56	0.75	0.61
	sand	0.25	0.12	0.09
	aggregate	....	0.12	0.19
1 inch thick	cement	0.74	1.00	0.81
	sand	0.33	0.15	0.13
	aggregate	....	0.15	0.26

TABLE 57.—QUANTITIES OF MATERIAL REQUIRED PER 100 SQUARE FEET OF FLOORS, SIDEWALKS, SLABS, ETC.—(*Continued*)

		Base course		
		1–3 mix	1–1–1 mix	1–1–2 mix
1½ inch thick	cement	1.17	1.50	1.21
	sand	0.50	0.22	0.19
	aggregate	....	0.22	0.38
2 inches thick	cement	1.54	2.00	1.62
	sand	0.58	0.30	0.25
	aggregate	....	0.30	0.50

In addition to the necessary labor of handling the materials and mixing the concrete, the following labor must be included in the estimate:

TABLE 58.—LABOR ON FLOORS AND WALLS, ETC.

	Hours
Per 100 square feet finish:	
Carpenters' setting screeds	0.4
Cement finishers	3
Per 100 linear feet plain base:	
Carpenters' setting grounds	1.5
Cement finishers	3
Per 100 linear feet sanitary base:	
Carpenters' setting grounds	1.5
Cement finishers	4.5

It is also necessary to include all of the items of mixing, wheeling, hoisting, etc., that are involved.

When estimating floors or walks going on earth, it is essential to have an item in the estimate to cover excavating to the under side of the construction, and also any cinder or gravel course that may be specified.

For curbing, it is necessary to include the cost of finishing top and face, also curb-bar, if specified.

Example.—Compute the cost of a floor for an area 72 feet by 201 feet, including 6 by 1-inch sanitary base all

around. The floor is to consist of 4 inches of 1-2-4 base course and 1 inch of 1-2 top course. Distance to railroad 1½ miles over hard road. Distance to sand and gravel pit ½ mile over poor road. Excavation for floor by others. Use the following prices:

Cement finishers	65 cents per hour
Concrete laborers	50 cents per hour
Concrete foreman	65 cents per hour
Carpenters	85 cents per hour
Water boy	30 cents per hour
Teams	$1 per hour
Cement in cloth	$3 per barrel, f. o. b. cars
Sand	25 cents per yard in the pit
Gravel	25 cents per yard in the pit
Water rate	5 cents per cubic yard

Area to be covered.

$72 \times 201 = 14{,}472$ square feet

Length of base.

$(2) \times 72 = 144$

$(2) \times 201 = 402$

546 linear feet = 273 square feet

Materials required (from Table 57).

	Barrel cement	Yard sand	Yards gravel
Base course	1.80	0.54	1.10
Top coat	0.99	0.30	
Total per 100 square feet	2.79	0.84	1.10

For floor $2.79 \times 144.72 = 403.8$
For base $0.99 \times 2.73 = 5.5$
409.3 barrels cement @ $3 . . . . . . $1,227.90

For floor $0.84 \times 144.72 = 121.6$
For base $0.30 \times 2.73 = 0.8$
122.4 yards sand @ $0.25 . . . . 30.60

For floor $1.10 \times 144.72 = 159.2$ yards gravel @ $0.25 . . . . 39.80

Water @ 5 cents per cubic yard of concrete 8.00

Total for materials $1,306.30

Hauling

	Hours		
Cement, 15 barrels per load, 28 trips @ 1.25	35		
Waiting time, 28 trips @ 0.67	19		
Sand and gravel, 0.74 cubic yard per load, 380 trips @ 0.24 hours	91		
Waiting time, 380 trips @ 0.16 hours	61		
Total team time @ $1.00	206		$206.00

Laborers

Load and unload cement, 410 barrels @ 0.06	25		
Load sand, 123 yards @ 0.50	62		
Load gravel, 160 yards @ 0.65	104		
Charge cement into mixer, 410 barrels @ 0.10	41		
Charge sand into mixer, 123 yards @ 0.61	75		
Charge gravel into mixer, 160 yards @ 0.61	98		
Attend mixer, 1,680 batches @ 0.025	42		
Spread concrete, 1,680 batches @ 0.025	42		
Wheel concrete, 160 yards @ 0.77	123		
	612	@ $0.50	$306.00

Carpenters

	Hours		
Setting screeds for finish, 145 squares @ 0.4	58		
Setting screeds for base, 546 linear feet @ 1.5 per 100	8.2		
	66.2	@ $0.85	$ 56.27

Finishers

	Hours		
On finish, 145 squares @ 3 hours	435		
On San. base, 546 linear feet @ 4.5 hours per 100	246		
	681	@ $0.65	$442.65

Mixer Expense

$\frac{1,680 \text{ batches}}{120 \text{ per day}}$	14 days	@ $5.00	$70.00

Foreman

14 days or	112 hours	@ $0.65	$72.80

SUMMARY

Materials	$1,306.30
Hauling	206.00
Laborers	306.00
Carpenters	56.27
Finishers	442.65
Mixer expense	70.00
Foreman	72.80
Insurance on teams	6.18
Insurance on payroll	47.71
Contingencies	120.00
Cost	$2,633.91

NOTE.—There will be a credit against this amount for the number of bags actually returned. On a job under average conditions this credit would be 1,227 bags @ 10 cents, or $122.70.

Instead of pursuing the method just outlined, many estimators prefer to calculate the cost of all of the items per square foot, or per hundred square feet, and to multiply the total area by the unit price thus obtained.

The principles and results are the same in either case, and it is purely a matter of choice as to which method is used.

SECTION VI. REINFORCED CONCRETE WORK

At the outset, grateful acknowledgment is made to K. R. Wagner, Secretary, George W. Stiles Construction Co., Chicago, for the very kind assistance rendered by him in furnishing data and in making helpful suggestions that were used in the preparation of this Section.

A reading of the earlier sections in this chapter and the previous chapter has conveyed a knowledge of the methods to be employed in:

Delivering materials to the site of the work.
Handling the materials to the mixer or mixing board.
Mixing under most ordinary circumstances.

Placing concrete in forms.
Building simple forms.
Placing unassembled reinforcement.

It is not necessary, therefore, to make any attempt to go over the ground that has previously been covered, but rather, as quickly as possible, to attack those problems in estimating the cost of reinforced concrete that differ essentially from the problems encountered in estimating the cost of plain concrete work.

Usually plain concrete building construction will be 1-3-6, or 1-2½-5 mix, but most of the reinforced work will be 1-2-4 mix, while the columns will probably be somewhat richer, depending upon the loading.

Since each variation in the mixture changes the money cost of the materials used, as well as the amount of labor involved, in handling the ingredients of a cubic yard of concrete, each class of concrete should be figured separately.

Rules for Scaling Quantities.—The following rules should be observed in scaling quantities:

Figure slabs to full over-all dimensions.

Figure beams and girders only to underside of slab.

Figure drop-heads as additions to slabs.

Figure all forms, except round columns and their splay-heads, by actual contact area.

Figure round column forms by listing the number of columns of each diameter and their lengths.

Figure reinforcing steel in pounds, by listing the quantities of each size and multiply by the weight per linear foot given in Table 43, Chapter V.

Placing Reinforced Concrete.—Having determined the quantities of concrete involved, and the costs of the materials required to produce them, it is possible from what has been learned from previous chapters readily to compute the cost of assembling those materials and mixing them into concrete.

Because the quantities to be handled are ordinarily very large in reinforced concrete buildings, as compared with

plain concrete work, the method and equipment used are essentially different.

Of course, on a small job, even though it should be reinforced concrete, the work to be done, if it be under 200

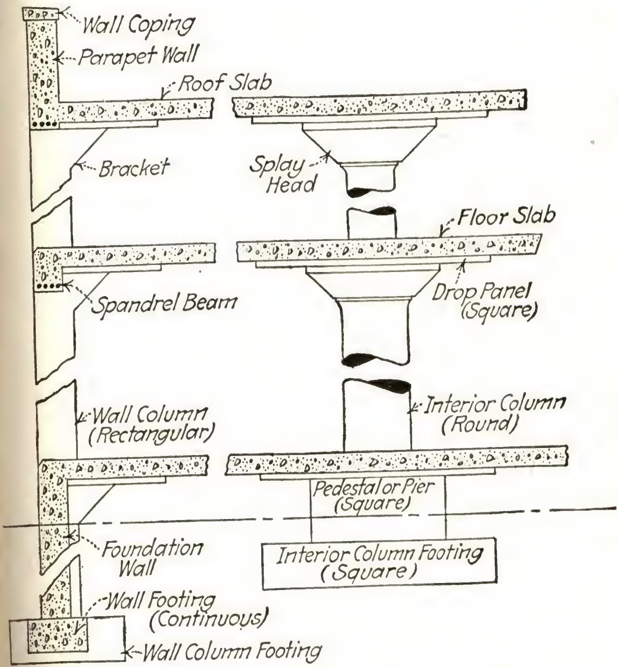

Fig. 12.—Typical reinforced concrete details.

cubic yards, will not ordinarily warrant the use of any complicated plant and the methods used for placing plain concrete will apply; but, because of the additional care required properly to surround all steel with concrete, the cost of spreading will be practically doubled.

Of course, since the organization will be proportioned to take care of the full production of the mixer, the number of men required for spreading will be the same whether

the placing be done by wheelbarrows, carts, chutes or other device.

While a man can wheel about three times as much concrete in a two-wheel cart as he can in a barrow, the lost time in turning and the necessity for heavier and wider runs, makes it impossible to show a proportionate saving in cost.

With carts, instead of figuring that a man will move 35 cubic feet a distance of 40 feet per hour, we can assume a figure of 55 cubic feet for the same distance.

We have now only to consider the costs of elevating the concrete to be distributed by carts and the cost of handling it by elevating buckets and chutes.

Working continuously, a two-barrow elevator can hoist the equivalent of 2,700 cubic feet per 1 foot per hour in barrows, or 8,000 cubic feet per 1 foot per hour in carts.

These figures may be considered the limit of capacity for a platform elevator as ordinarily operated, but in most cases the amount handled will be determined by the capacity of the mixer and the daily fixed charge for the elevator must, therefore, be distributed over the number of cubic yards of concrete produced.

Thus, if the mixer is delivering only 3.5 cubic yards per hour, its production per 8-hour day would be 28 cubic yards and at a daily elevator cost of $20, the charge would be $0.714 per yard.

When chutes are used, it is possible to arrange for hoisting capacity well adjusted to the mixer capacity, so that the fixed daily cost of the chuting plant is to be divided by the number of yards delivered in order to determine the hoisting and chuting cost per yard.

If the plant is rented, or if a rental rate has been fixed for it, the problem is simple; otherwise it is necessary to calculate the cost of delivering the plant to the work, setting up, maintaining it, dismantling it and returning it to headquarters, as well as allowance for depreciation. This estimated cost is then divided by the number of yards to be placed in order to obtain the charge per yard.

Often, even though the plant is rented, the user pays all charges from the time it is loaded on cars at headquarters until it is returned there, so practically the same process must be gone through.

The cost of freight can, of course, only be ascertained by determining the weight of the equipment and inquiring of the transportation company.

The cost of hauling or trucking and unloading can be determined by methods previously outlined.

Erection and Dismantling.—The cost of erecting and dismantling a chuting plant is approximately 2 hours labor or carpenters' time per foot of height and the tower must be built high enough above the highest point at which concrete is to be deposited to allow the elevating bucket to discharge into the hopper and for the chutes to have sufficient pitch from hopper to point of deposition so that the concrete will flow properly.

This pitch is given by Hool and Johnson, in "Concrete Engineers' Handbook," as follows:

For a distributing distance of 50 feet, pitch 1 in 6
For a distributing distance of 100 feet, pitch 1 in 4
For a distributing distance of 300 feet, pitch 1 in 3

Beside this, allowance must be made for the height of the swivel joints at each change of direction of a chute. All this really means that it is necessary to have the plant pretty well in mind when estimating.

SECTION VII. FORMS FOR REINFORCED CONCRETE

If it were feasible always to make a design of the form-work for a given building before submitting the estimate, it would be advisable to estimate the cost by methods similar to those given for estimating the costs of timber construction and of planking, but since it is seldom that sufficient time is available for such detailed work, it has become customary to make practically all estimates upon the basis of the area of forms in contact with concrete.

For that reason, we shall confine ourselves to a discussion of the contact area method in this Chapter, since Chapter VII contains sufficient data to enable use of the more detailed method whenever desired.

TABLE 59.—FORMS FOR REINFORCED CONCRETE CONSTRUCTION
(Hours per 100 square feet)

	Assembling		Erecting		Stripping
	Carpenters	Helpers	Carpenters	Helpers	Laborers
Square columns........	6.5	2	2	2	3.5
Spandrel beams........	5.5	2	2	2	3.5
Beams and girders......	6.0	2	2	2	3.5
Brackets and heads....	8.5	3.5	3	3	3.5
Drop panels............	6.5	3	2.5	2.5	3
Slabs..................	6.5	1.5	1.5	1.5	3
Walls and partitions....	5.5	3	3	2	3.5
Stairs.................	8.5	3	3	3	3.5

NOTE.—To obtain the total cost of forms, the cost from each of the five columns above must be combined; where forms can be re-used, the assembling cost need only be figured once.

On an ordinary reinforced concrete building the forms become practically a complete structure in themselves, so it is rather difficult to determine just what portion of the lumber is chargeable to the different items of formwork, but for all ordinary purposes the data in Tables 59 and 60 will be found sufficiently accurate.

However, experience has shown that a fair average of the amount of lumber required to construct forms in reinforced concrete buildings is as follows:

Boarding..........................	1.15 FBM
Studding, etc.....................	2.65 FBM
Total..........................	3.80 FBM

though some writers figure as low as 3 FBM per square foot.

It is seldom necessary to install all of the forms at once, and therefore, they can be used again. On the other hand, beam bottoms, posts, etc., must be left in place longer than the other portions of the formwork, so it is not possible to divide the quantity of material needed to build a form once by the number of times it is to be used, in order to determine the correct amount of material to be figured for each of the total number of square feet of forms to be made.

In fact, the actual speed of construction forms such an important factor in determining the amount of reposting that must be done, as well as the number of times the forms can be used, that it is almost impossible to determine the exact amount of lumber required.

Speed Highly Important.—However, the figures given in Table 60 are based upon past experience and are, therefore, safe to use under all ordinary circumstances.

TABLE 60.—LUMBER QUANTITIES FOR FORMS
(Speed: two weeks per story. Feet board measure per square feet of contact area)

Height of building, stories	FBM	Percentage of increase for speed of one story per week
1	3.8	
2	3.8	30
3	3.3	60
4	2.5	80
5	2.1	70
6	1.8	65
7	1.6	72
8	1.5	60
9	1.4	65
10 or over	1.4	50

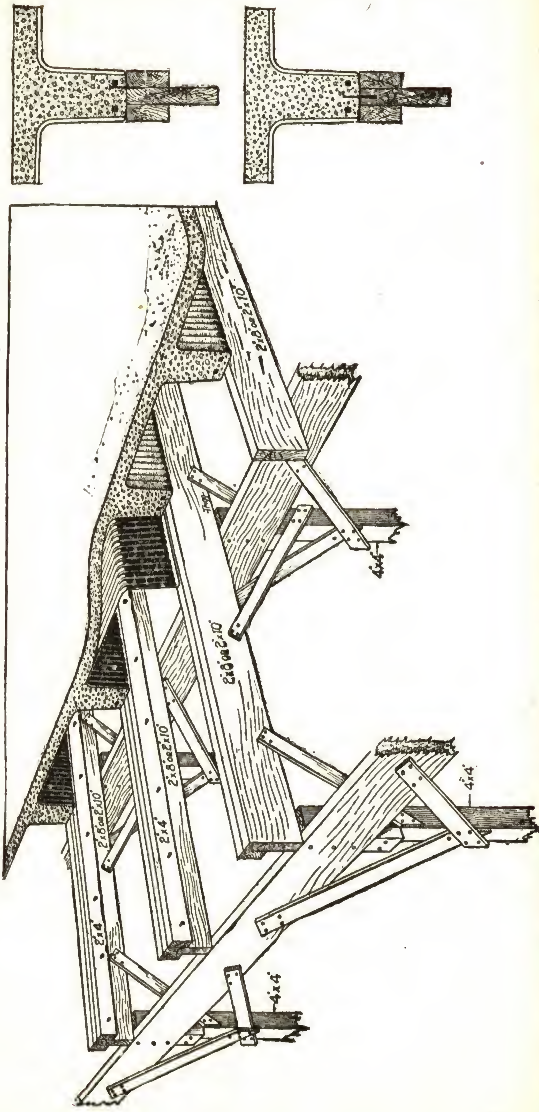

FIG. 13.—Forms for ribbed concrete floors. (*Courtesy Berger Manufacturing Co.*)

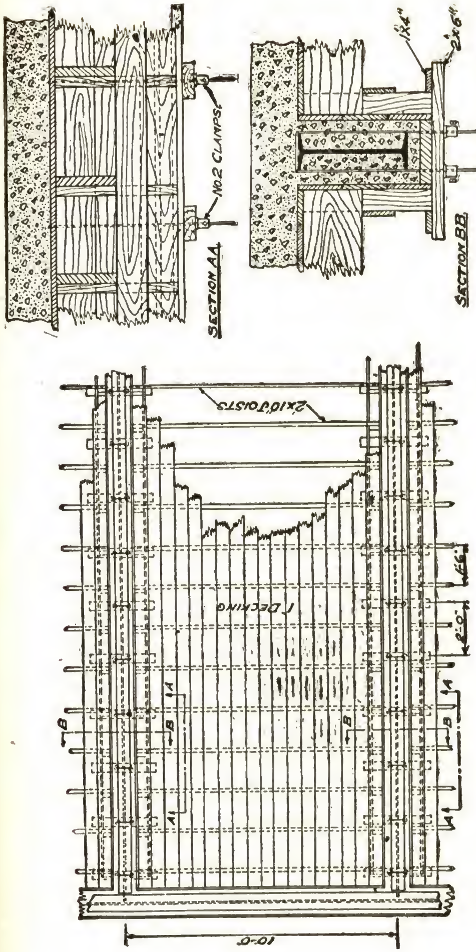

FIG. 14.—Floor forms supported on steel construction. (Courtesy Universal Form Clamp Co.)

Table 59 gives the basis for figuring labor costs of concrete formwork by the contact area method.

The same remarks, as made under the heading of forms for plain concrete work, regarding the costs of moving from stock-pile, re-building forms, and salvage, apply to the forms covered by Table 60.

Table 60 is based upon the ordinary rate of speed of one story each two weeks; increasing the speed to one story per week will increase the total quantity of lumber to be used by the percentages given in the table.

Round Column Forms.—Steel round column forms are usually furnished upon a rental basis by the companies who manufacture them and it is their custom to make a lump-sum price for the complete installation and removal of the forms on an entire building.

Sometimes, however, the column forms are purchased outright by the builder, or rented without any service. In these cases, the cost of freight to and from the work, rent (or depreciation) and erection and removal must all go into the estimate.

The price (or rental) and freight must in each case be determined by inquiry. The best method is to send a complete schedule of the columns, by floors, to the column companies, giving diameter of columns, length from floor to underside of slab (or drop-panel) and dimensions of capitals.

The time required to install one column form, including the capital, remove it after pouring and clean it for re-use, will average 16 hours. The work can be done by handy men, under the direction of a carpenter, but Union rules may require it to be done by iron-workers.

Placing Reinforcing Steel.—In Tables 43 and 44, Chapter V, information is given as to the method of figuring the cost of reinforcing steel for all comparatively plain work.

The times given in Table 44 for placing may be used for all slab work, except where the use of spacing bars or other devices is specified or for beams which are assembled

in units with stirrups, or other shear members, or columns with hooped or spiral reinforcement.

The times given in Table 44 for bending should be used in all cases where it is desired to figure the bending separately.

When taking quantities from plans, it is essential that complete lists be made of all spacers, patent ties, supports, inserts, and all other specialties that are required and to figure their cost at prices to be obtained from the manufacturers or dealers, as well as the cost of installation.

Tables 61, 63 and 64 give the data for calculating the cost of placing reinforcing steel under various conditions in a building.

TABLE 61.—BENDING AND PLACING REINFORCING STEEL

	Hours per ton				
	Bending		Placing		
	Beams, columns, stairs	Walls, slabs	Walls, beams, columns, stairs	Diagonally reinforced slabs	Plain slabs
¼	5.5	3.25	17.0	12.5	12.0
½ and ⅝	5.0	2.75	12.0	8.5	8.0
¾	4.5	2.25	7.5	6.0	5.5
1 and over	3	2	4.5	3.5	3.0

TABLE 62.—MATERIALS FOR TAR CONCRETE

Size of Aggregate	Gallons per Cubic Yard
1- to 2½-inch crushed stone	6
¼- to 2½-inch crushed stone	9
Coarse screened gravel	7
Fine screened gravel	10
Sand (for dampproof course)	50 to 60

Because of the great number of items that would result, with ensuing complication of the estimate, it is not advisable to adhere to the method of listing the number of bends in each size of bars when figuring a large reinforced concrete structure, but the tonnage of bars should be kept separate; first, because the cost per ton of bending and placing steel increases as the weight in pounds per foot of bar decreases and, second, because the price per ton increases on all sizes below ¾ inch. Dealers also make an additional charge for rods cut to short lengths.

Some of the companies exploiting particular types of reinforcing bars make a practise of quoting lump-sum figures for all of the steel, cut, bent and ready for assembly, according to the plans and specifications but others only quote unit prices with extras for cutting and bending.

When sending lists for quotations, it is best to give the number of pieces of each size and length required, together with diagrams showing any bending required.

This work is claimed by the metal-lathers or iron-workers, in most parts of the country, but can readily be learned by handy men working under competent direction.

Surface Finishes.—In a previous section we discussed how to compute the cost of any of the ordinary kinds of surface finish used on concrete work, as well as the cost of granolithic and similar floors.

There are many different forms of special finishes that may be applied to concrete surfaces but the most usual methods of improving the wearing surfaces are by introducing metallic hardeners into the top coat or by coating the surface with liquid hardeners or waterproofing compounds.

Most of the liquid compounds require from ¼ gallon to ½ gallon of material and ½ hour of labor per 100 square feet of surface for each application. The amount of material, however, depends upon the consistency of the compound as well as upon the porosity of the surface, so it is well to get definite figures as to the covering capacity of any compound under consideration.

Where metallic hardeners are used, they should always be applied in strict accordance with the manufacturers' directions, for the kind of service required by the specifications.

These directions will give the quantities of hardener to be used as well as the quantities of sand and cement.

The labor items are to be figured as previously explained.

TABLE 63.—RIBBED CONCRETE FLOORS
(Labor on forms and pans per 100 square feet)

	Hours
Carpenters, building forms	6.3
Helpers, building forms	3.1
Laborers, stripping forms	3.3
Helpers, setting pans	5.5[1]

[1] Where union rules apply, this must be done by iron-workers.

TABLE 64.—RIBBED CONCRETE FLOORS
(Quantities per 100 square feet)

Construction	Width of rib	Cubic yards, concrete	Pounds, steel[1]	Pounds, steel[2]
6 plus 2	4	1.18	233	219
6 plus 2	5	1.24	233	219
8 plus 2	4	1.34	250	235
8 plus 2	5	1.41	250	235
10 plus 2	5	1.59	269	252
10 plus 2½	5	1.75	311	291
10 plus 3	5	1.91	349	327
12 plus 2	5	1.80	284	267
12 plus 2½	5	1.96	337	315
12 plus 3	5	2.12	371	347
12 plus 3	6	2.21	371	347

NOTE.—Weight of steel includes temperature rods at right angles to ribs but does not include weight of pans.

[1] Weight in this column figured on basis of fs. 16,000, fc 650.

[2] Weight in this column figured on basis of fs. 18,000, fc 700.

TABLE 65.—CONCRETE COLUMN QUANTITIES
(Cubic yards per 100 linear feet)

Diameter, inches	Round column	Octagonal column	Square column
6	0.74	0.77	0.93
8	1.28	1.37	1.65
10	2.02	2.14	2.58
12	2.82	3.08	3.71
14	3.96	4.18	5.04
16	5.12	5.48	6.60
18	6.55	7.92	8.40
20	8.08	8.56	10.32
22	9.70	10.40	12.45
24	11.28	12.32	14.88
26	13.80	14.40	17.40
28	15.84	16.72	20.16
30	18.10	19.15	23.10
32	20.24	21.92	26.40

TABLE 66.—CONCRETE BEAM QUANTITIES
(Cubic yards per 100 linear feet)

	Width in inches				
Depth	6	8	10	12	14
8	1.24	1.64	2.05	2.46	2.88
10	1.55	2.05	2.56	3.08	3.60
12	1.86	2.46	3.08	3.72	4.32
14	2.17	3.07	3.60	4.33	5.04
16	2.48	3.28	4.10	4.96	5.76
18	2.79	3.69	4.61	5.54	6.48
20	3.10	4.10	5.12	6.16	7.20
22	3.41	4.51	5.64	6.80	7.92
24	3.72	5.92	6.16	7.44	8.64

TABLE 67.—PLAIN SLAB QUANTITIES
(Cubic yards concrete per 100 square feet)

Thickness, inches	Quantity	Thickness, inches	Quantity
1	0.31	6½	2.04
1½	0.47	7	2.20
2	0.62	7½	2.35
2½	0.78	8	2.50
3	0.93	8½	2.65
3½	1.09	9	2.80
4	1.24	9½	2.95
4½	1.40	10	3.10
5	1.56	10½	3.25
5½	1.72	11	3.40
6	1.88	11½	3.56
		12	3.71

NOTE.—See also Tables 49 and 53 on pages 93 and 100 for quantities of materials required.

CHAPTER VII

TIMBER FRAMING

SECTION I. GENERAL

When the writing of this text was considered, the paucity of the published data available regarding the cost of timber framing was astonishing. True, a great deal of information has been published but it is all on the basis of the cost per thousand feet B.M.

If all designers used the same details in mill construction, for instance, then a figure per thousand feet for that type would have a real value. But rather costly experience has shown that the only safe way to determine the probable cost of a sizable job of mill construction is to determine the several operations that must be performed on each stick and to estimate them separately.

This is not so formidable a task as it sounds. There are generally a great number of sticks all exactly like one another in every mill construction building. That is, on any floor most of the columns will be alike, most of the inner rows of floor timbers will be alike and most of the outer rows of floor timbers will be alike.

Therefore, having found the cost for one stick, it is only necessary to multiply it by the number of similar sticks.

In a recent instance of a building, the cost of framing was figured on the basis of figures taken from previous experience and those figures also very closely approximate certain previously published cost figures. The estimate was:

2 carpenters 8 hours each @ .85........	$13.60
3 laborers 9 hours each @ .45..........	12.15
To frame 2,000 FBM..................	25.75
Estimated cost per 1,000...............	13.88

The actual cost was over $20 per M and the job superintendent claimed that the number of operations on each stick made it impossible for him to show a lower cost.

Note that the term "framing" as used so far, includes the actual framing operations as well as the operations of erecting, and most published data follow the same plan. Experience has shown that it is wiser to estimate the cost of those two distinct operations separately. If one gets into the habit of figuring each distinct operation separately, he will find that the temptation to "lump" and guess is greatly lessened and that his estimates more nearly approach actual costs.

Use your "costs per thousand" as a check on your detailed figures, if you like, but be sure to study the details.

You have already learned how to compute the cost of hauling materials when the weight is known, so if you know the weights of the various kinds of building lumber, you can readily figure the cost of hauling it from a car or yard to the work. Table 68 gives that information.

TABLE 68.—WEIGHTS OF TIMBER

	1,000 FBM per ton		Pounds per 1,000 FBM	
	Rough	Dressed	Rough	Dressed
Yellow pine...	0.455	0.57	4,400	3,500
Chestnut......	0.657	0.70	3,050	2,850
Red oak......	0.597	0.638	3,350	3,140
White oak.....	0.56	0.615	3,575	3,250
Spruce........	1.07	1.15	1,860	1,740
Hemlock......	1.07	1.15	1,860	1,740

NOTE.—Very complete tables of the weights of many kinds of timber and lumber may be found in the "Yellow Pine Manual," the handbook of the Southern Pine Manufacturers' Association, and the "Pocket Companion" published by Carnegie Steel Co.

Of course, the cost of handling varies greatly, depending upon whether the lumber is taken from a box-car, a gondola,

or a flat-car, or whether it is taken from a pile. The type of trucks or wagons used also have an effect upon the cost; for instance, the "roller-dump" type of trucks and wagons used in many places can be unloaded in less than a minute, while other types require a very appreciable time of unloading.

Costs of handling timber from cars to trucks may be figured from Table 69.

TABLE 69.—AVERAGE COSTS ON UNLOADING TIMBER AND LUMBER FROM CAR

(Labor hours per 1,000 FBM)

	From flat-car	From gondola car	From box-car
Heavy mill timbers	1.0	1.5	1.0
House framing	0.4	0.5	0.5
Floor and roof plank	0.6	0.7	0.7
Boards	0.4	0.5	0.5
Flooring	0.7	0.8	0.8

Unloading from truck to pile will be two-thirds of the time required from flat-car to truck.

SECTION II. MILL CONSTRUCTION

Scaling the quantities for a mill construction building is a comparatively simple operation, but estimating the cost is not so simple, since, on a carpenter's wage rate of 70 cents per hour, the cost per thousand feet BM may easily vary from \$7 to over \$20.

This is all explained by the variation in details, one designer uses joint-bolts to provide a cross-tie for the building, another uses dog-irons, another depends entirely upon the lag-bolts in the column-caps.

Some designers use cast-iron pintles to carry the load of an upper column to the capital of the column below,

while other designers permit the column itself to come down into the capital.

TABLE 70.—FRAMING MILL TIMBERS

(Hours of carpenters' time per cut)

	Thickness of timber, inches				Any size
	8	10	12	16	
Crosscutting, per inch of depth......	0.04	0.05	0.06	0.07	
Ripping, per linear foot.............	0.14	0.16	0.20	0.28	
Chamfering, per linear foot..........	....	....	....	....	0.02
Drilling ¾-inch or smaller holes.....	....	....	0.02		
Drilling 1-inch holes................	....	....	0.03		
Drilling 1½-inch holes...............	....	....	0.04		
Cutting mortise for knee brace.......	....	....	....	....	0.30
Cutting V notch for pintle...........	0.22	0.26	0.30	0.42	
Cutting square notch for post........	0.25	0.30	0.35	0.50	
Cutting mortise for joint bolt.......	0.10	0.12	0.15	0.20	
Cutting notch for hook plate.........	0.12	0.15	0.18	0.20	

All of these variations in design introduce operations which must be considered when estimating. Table 70 gives the time in hours of carpenters' time for a number of different operations. Where the operation, such as cross-cutting, requires two men, proper allowance has been made in the table so that the figures may be used without change.

The figures in the table include an allowance to cover the time of shifting the boring-machine and other tools, as well as moving the sticks into working position, turning them as required, and also moving the stick out of the way when framing is completed.

Example.—An example of the method of figuring the cost of framing is as follows:

The floor beams in a certain silk mill are 10 by 18's, 24-0 long. They are carried on duplex hangers at one end and on hook plates at the other. The table only takes

in sizes as high as 16 inches, so we will make proportionate allowances where necessary.

	Hour
Plumb-cut at girder end	0.90
Fire-cut at wall end	0.90
Notch for hook plate	0.15
Chamfering 2 under corners, 22 feet each	0.88
	2.83
	@ $1.125 = $3.18

Each stick contains 360 FBM, therefore the cost of framing 1,000 FBM would be $8.83 for the floor beams.

The girders are 10 by 18's, 16-0 long, carrying a beam on each side every eight feet, the beams being supported by hangers which are let into the sides of the girders by two holes. The girders have a plumb-cut on each end. The cost is, therefore,

	Hour
Plumb-cuts at both ends	1.80
Drilling 4 holes for beam hangers, holes 4 inches deep	0.16
Drilling 4 holes for dog-irons	0.04
Chamfering 2 under edges	0.56
	2.56
	@ $1.125 = $2.88

Each stick contains 240 FBM, so the cost per thousand is evidently $12 for the girders.

The columns are 10 by 10's, 12-0 long, requiring only square cuts at top and bottom to fit into iron bases and caps. Their cost is:

	Hour	
2 square cuts	1.00	
Chamfering 40 linear feet	0.80	
	1.80	@ $1.125 = $2.03

Each column contains 100 FBM, so the cost is evidently $20.30 per M for the columns.

This brings out one of the most dangerous features of the usual method of figuring on the basis of an assumed average hourly production or a cost per thousand feet. The columns, though each of them requires considerably less

work on it than each of the floor beams requires, cost more than twice as much per thousand feet.

This is simply because the columns each contain less than half as many board feet as the beams do. This same condition exists throughout most jobs; for instance, a 6 by 6 column will contain only one-fourth as much material as a 12 by 12 column, yet the cost of framing it will probably be more than half as much as the cost of framing the 12 by 12. This will result in a cost per thousand that will be twice as high for the small sticks as for the large ones.

This same mill has a truss-roof on the top story. Each truss contains:

Chords	6 by 8	1/22–0	1/26–0	192
Rafters	6 by 8	2/24–0	......	192
Struts	6 by 6	2/ 8–0	2/ 7–0	90
	4 by 6	2/ 6–0	......	24
				498

The labor cost of assembling one truss will be:

	Hour
End cuts on chords and rafters	1.92
End cuts on struts	2.16
Boring chord and rafter for 4 end bolts	0.22
Boring chord and rafter for 5 truss rods	0.20
Boring chord for 12 splice bolts	0.18
Notching chord and rafter for struts	3.00
Notching chord and rafter for rods, etc	3.50
Bolting up truss	2.00
	13.18
	@ $1.125 = $14.83

Since the truss contains 498 FBM, the cost per thousand FBM is evidently $29.78.

Erecting Timber.—So far we have only figured the cost of framing. We must still estimate and add in the cost of the erection.

The cost of erection is a very variable item and will depend upon the equipment available, the height to which

the timber must be raised above ground, the distance between timbers, and whether or not most of the work can be done by common laborers instead of carpenters.

While framing timber is very properly a carpenter's job, there is no good reason why practically all of the work of erection cannot be done by good laborers, working under a competent carpenter foreman. However, in certain districts, the Unions may enforce regulations requiring that the work be done by carpenters.

For most mill jobs, the best sized gang will consist of eight men, using a hand-powered "wheel-derrick" and working as follows:

1 foreman,
4 laborers operating the derrick,
1 laborer tending guy line,
1 carpenter putting the timber in place,
1 laborer helping the carpenter.

Such a gang can handle timbers containing up to 400 FBM, each at the following speeds:

Table 71*A*.—Erecting Timber
(Time for full gang, as above)

Shifting derrick horizontally	2 feet per minute
Raising timber vertically	3 feet per minute
Setting timber in place	Average 5 minutes

Table 71*B*.—Erecting Mill Timbers
(Average in hours per 1,000 FBM)

	Beams	Columns	Trusses
Carpenters	3.0	10.0	4.8

Add to the carpenters' time, the following:

	For each 100 feet of horizontal travel	For each 10 feet of vertical lift
Laborers[1]	3.5	3.5

[1] Union rules may make it necessary for this work to be done in all or part by carpenters.

These unit times contain a sufficient allowance to cover the ordinary small delays that occur in a day's work, but do not provide for any major contingencies.

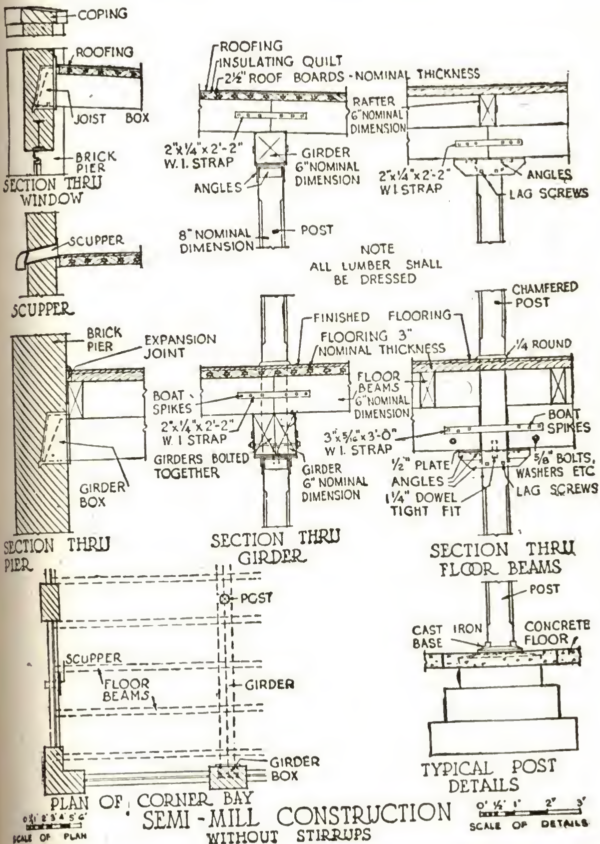

FIG. 15.—Mill-construction details. (*Courtesy National Lumber Manufacturers' Association.*)

Individual timbers containing over 400 feet BM are seldom encountered in ordinary mill construction (though we once handled a mill in Paterson, N. J., with timbers of

1,728 FBM, each, which is very exceptional) and the cost of erection per stick will advance practically one and one-half times its proportionate size beyond 400 FBM.

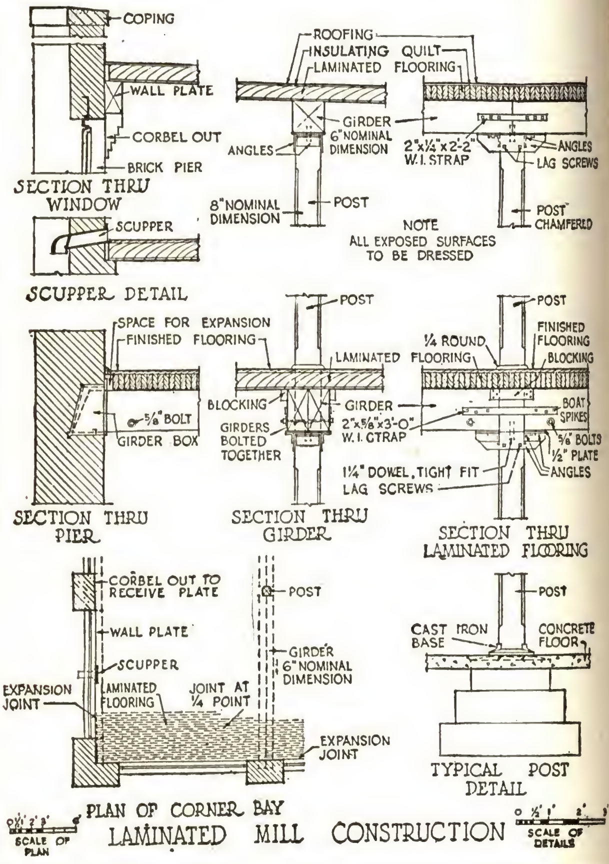

FIG. 16.—Mill-construction details. (*Courtesy National Lumber Manufacturers' Association.*)

On the other hand, it takes practically as long to erect smaller timbers, until their size gets down below 200 FBM each, so the cost of erection per thousand feet becomes

less as the size of the individual sticks increases until it reaches 400 feet per stick, after which it again advances.

In multi-story buildings there will usually be a steam-engine or electric-motor on the job for use in raising other

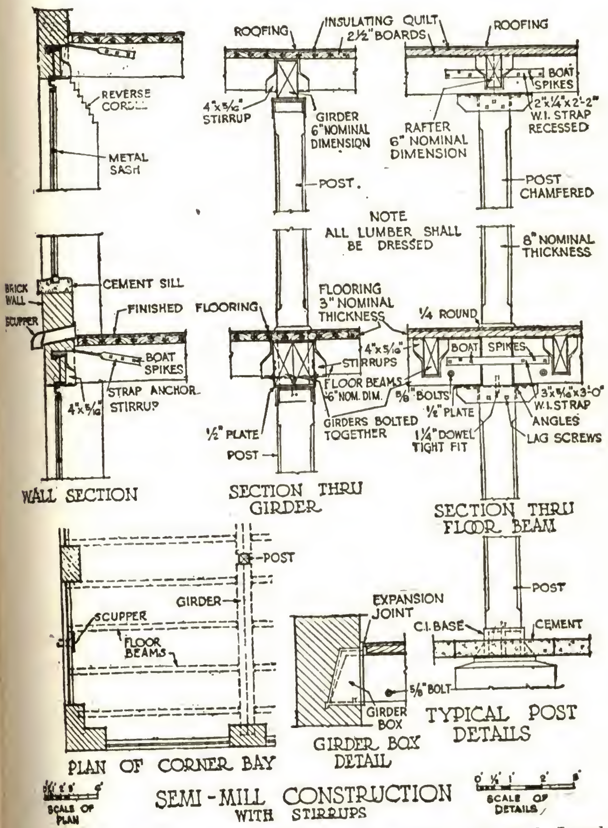

FIG. 17.—Mill-construction details. (*Courtesy National Lumber Manufacturers' Association.*)

materials and it can also be employed in getting the timber onto the upper floors, from whence it can be erected by the hand-powered derrick. In some cases the entire erec-

tion is handled by a power-derrick, but I believe the number of instances where this can be done economically is comparatively few.

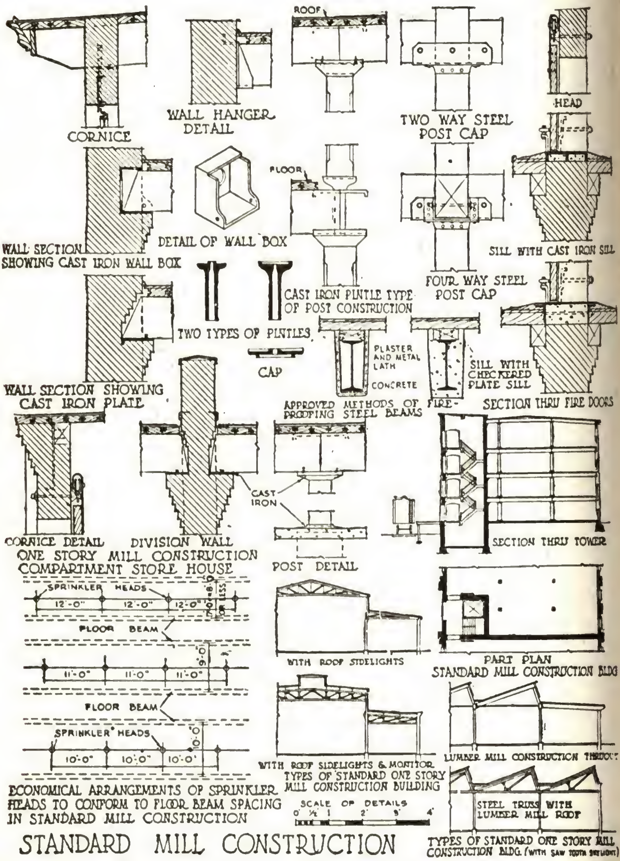

FIG. 18.—Mill-construction details. (*Courtesy National Lumber Manufacturers' Association.*)

Where the hoisting-engine is employed to lift the timbers onto the floors, it is usual to wrap the line around the winch or "nigger-head." Working this way will require two men

on the ground to "load" the timber, two men on top to "unload," one man to tend the winch and the engineer to operate the derrick.

Such a gang should "load" and "unload" in a total of three minutes and should handle loads averaging 800 feet BM at a speed of 12 vertical feet per minute.

Applying these figures to the building under consideration, we get the following costs:

Cost of "Wheel-derrick" Gang per Hour

Foreman	$1.25
6 laborers @ $0.45	2.70
Carpenters	1.12½
(Average 0.634)	$5.07½

Cost of "Power Hoist" Gang per Hour

Foreman (working)	$1.25
3 laborers @ $0.45	1.35
Guyman	0.50
Engineer	1.00
Engine	1.00
(Average 0.734)	$5.10

Erecting Second Story Timbers (from first floor)

Timbers are 8 feet center to center

	Minutes
Shifting derrick	4
Raising timber	4
Setting timber	5
	13 minutes = 0.22 hour

The third and fourth story timbers will take the same length of time to erect, plus the time taken to bring them to the floors from which they are erected.

Thus third story timbers will require the time of the "power hoist" gang for each "load" as follows:

	Minutes
Load and unload	3
Hoist	1
Total	4 minutes or 0.07 hour

The fourth story timbers will require 1 additional minute of hoisting time, making 5 minutes, or 0.084 hour.

The cost of erecting, exclusive of hoisting, is therefore:

For beams, 0.22 hour × \$5.07½ ÷ 360 = \$ 3.10 per 1,000
For columns, 0.22 hour × \$5.07½ ÷ 100 = \$11.17 per 1,000
For girders, 0.22 hour × \$5.07½ ÷ 240 = \$ 4.65 per 1,000

From their sizes it can be seen that two beams or three girders will just about make a "load" for the hoist. The columns could be hoisted eight at a time, so far as weight is concerned, but their shape makes it unlikely that more than four will be handled at once. Therefore the third-story hoisting cost will be:

For beams or girders, 0.07 hour × \$5.10 ÷ 720 = \$0.60 per 1,000
For columns, 0.084 hour × \$5.10 ÷ 400 = \$1.08 per 1,000

In handling the trusses, the time for shifting the derrick will be the same as before, but even though each truss contains only 498 FBM, the time taken in hoisting and erecting it, because of its size and shape, will be twice as long as for a stick, and the time placing it three times as long. Since all the trusses go on one level, we can figure them as follows:

	Minutes	
Hoisting gang time:		
Load and unload	6	
Hoisting 36 feet	6	
	12 minutes or 0.20 hour	
	@ \$5.10 =	\$1.02
	Minutes	
Wheel derrick gang:		
Shift derrick as before	4	
Raising truss	12	
Setting truss	15	
	31 minutes or 0.51 hour	
	@ \$5.07½ =	2.60
	Total...	\$3.62

which equals \$7.27 per 1,000

NOTE.—For convenience sake, it might have been better, as well as cheaper, to have hoisted the individual parts of the truss to the top floor and then assemble and erect them there. Where the element of time does not make it necessary to have the trusses ready to erect as soon as the walls can receive them, it will usually be found most economical to assemble them on the floor from which they are erected.

Summarizing the cost computed thus far, we get the following costs per 1,000 FBM:

	Framing	Hoisting	Erecting	Total
Beams:				
2nd floor.........	9.09	....	3.10	12.19
3rd floor.........	9.09	0.50	3.10	12.69
4th floor.........	9.09	0.60	3.10	12.79
Girders:				
2nd floor.........	12.00	....	4.65	16.65
3rd floor.........	12.00	0.50	4.65	17.15
4th floor.........	12.00	0.60	4.65	17.25
Columns:				
1st floor.........	20.30	....	11.17	31.47
2nd floor.........	20.30	0.89	11.17	32.36
3rd floor.........	20.30	1.08	11.17	32.55
Trusses............	29.78	2.04	5.23	37.05

Liability and compensation insurance, as well as overhead items and contingencies must, of course, be added to these figures. It must also be remembered that we have only figured the cost after the timber was delivered to the site of the work and that the cost of delivery must be computed separately.

Since, counting the working foreman as a carpenter, the usual average throughout such a job as this would be 1½ laborers to a carpenter, a much more usual method of figuring is as follows:

1 carpenter 8 hours @ $1.12½......................	$ 9.00
1½ laborers 8 hours @ 0.45........................	5.40
Cost to handle 1,000 FBM..........................	$14.40

This figure is to include framing, hoisting and erecting. To get the average for the building we have been studying we will figure as follows:

Second story:	
13,000 FBM beams @ $12.19	$ 158.47
2,200 FBM girders @ $16.65	36.63
900 FBM columns @ $31.47	28.32
Third story:	
13,000 FBM beams @ $12.69	164.97
2,200 FBM girders @ $17.15	37.73
900 FBM columns @ $32.36	29.12
Fourth story:	
13,000 FBM beams @ $12.79	166.27
2,200 FBM girders @ $17.25	37.95
900 FBM columns @ $32.55	29.30
Trusses:	
9,000 FBM @ $37.05	333.45
57,300 FBM @ average of $17.84	$1,022.21

This would indicate that, in this instance, the error by the use of the short method is practically 25 per cent, since the actual average daily production is only about 800 FBM, instead of 1,000 FBM as figured. However, the amount of this error would vary with each job, if there had been no trusses in this instance, the short method would have given a result that would be approximately the same as that obtained by the longer method. This simply indicates the necessity of separating the different classes of work, no matter which method of estimating is used.

TABLE 72.—MILL FRAMING TIMBERS
(Feet board measure per stick)

Size	Lengths, feet								Any length
	12	14	16	18	20	22	24	26	
6 × 6	36	42	48	54	60	66	72	78	L[1] × 3.0
6 × 8	48	56	64	72	80	88	96	104	4.0
6 × 10	60	70	80	90	100	110	120	130	5.0
6 × 12	72	84	96	108	120	132	144	156	6.0
6 × 14	84	98	112	126	120	154	168	182	7.0
6 × 16	96	112	128	144	160	176	192	208	8.0
8 × 8	64	74.7	85.4	96	106.7	117.4	128	138.7	5.333
8 × 10	80	93.4	106.7	120	133.4	146.7	160	173.4	6.67
8 × 12	96	112	128	144	160	176	192	208	8.0
8 × 14	112	130.7	149.4	168	186.7	205.4	224	242.7	9.333
8 × 16	128	149.4	170.7	192	213.4	234.7	256	277.3	10.67
8 × 18	144	168	192	216	240	264	288	312	12.0
10 × 10	100	116.7	133.4	150	166.7	183.4	200	216.3	8.333
10 × 12	120	140	160	180	200	220	240	260	10.0
10 × 14	140	163.4	186.7	210	233.4	256.7	280	303.4	11.667
10 × 16	160	186.7	213.4	240	266.7	293.4	320	346.7	13.333
10 × 18	180	210	240	270	300	330	360	390	15.0
10 × 20	200	233.4	266.7	300	333.4	366.7	400	432.7	16.6 67
12 × 12	144	168	192	216	240	264	288	312	12.0
12 × 14	168	196	224	252	280	308	336	364	14.0
12 × 16	192	224	256	288	320	352	384	416	16.0
12 × 18	216	242	288	324	360	396	432	468	18.0
12 × 20	240	280	320	360	400	440	480	520	20.0
12 × 22	264	308	352	396	440	484	528	572	22.0
12 × 24	288	336	384	432	480	528	576	624	24.0
14 × 14	196	228.7	261.4	294	326.7	359.4	392	424.7	16.333
14 × 16	224	261.4	298.7	336	373.4	410.7	448	485.4	18.667
14 × 18	252	294	336	378	420	462	504	546	21.0
14 × 20	280	326.7	373.4	420	466.7	513.4	560	606.7	23.333
16 × 16	256	298.7	341.4	384	426.7	469.4	512	554.7	21.333
16 × 18	288	336	384	432	480	528	576	624	24.0
16 × 20	320	372.4	426.7	480	533.4	586.7	640	693.4	26.667
18 × 18	324	378	432	486	540	594	648	702	27.0
18 × 20	360	420	480	540	600	660	720	780	30.0
20 × 20	400	466.7	533.4	600	666.7	733.4	800	866.7	33.333
24 × 24	576	672	768	864	960	1,056	1,152	1,248	48.0

[1] L = length in feet.

SECTION III. BUILDERS' IRON-WORK

Computing the quantities of builders' iron-work is ordinarily a very simple operation; the exact method to be used depends largely upon the kinds of iron-work called for.

For instance, if any of the ready-made or patented types of joist-hangers, beam-boxes, column-caps, column-bases and similar members are called for, the simplest method is to make a list of the various items required and get a price on the list, either from a catalogue or price-list or by inquiry of persons dealing in such goods.

When the iron-work consists of members made up of ordinary sizes of rod, bar, or flat-iron, the weight can easily be computed by means of the tables in such handbooks as Cambria, Carnegie or Lackawanna, or if no handbooks are available, all of the various sizes can be figured to the equivalent of one-inch square bar, which weighs 3.40 pounds per linear feet, and the total weight thus readily calculated.

Manufacturers of such iron-work will usually be glad to give a unit-price per pound of lists sent them for price, or a unit-price per piece on each of the various items.

Where castings of any ordinary types, such as bases, caps, bearing-plates, pier-plates, etc., are used, unless a price per piece can readily be obtained, the contents of each piece in cubic inches should be calculated, and since a cubic foot of cast-iron weighs 450 pounds, the weight of the piece will be found by multiplying its contents by 450 and dividing by 1,728. Many estimators simply divide the cubic contents by four and consider the result near enough for all practical purposes. See also p. 268, Appendix A.

A bricklayer with a laborer will set a base-plate, 16 inches square, and weighing 100 pounds in an average time of ½ hour and will take practically the same time for one of half that weight, while a beam bearing plate weighing 40 pounds, should not require over ten minutes.

With masons' time at $1.25 per hour and laborers' time at 60 cents per hour, the costs would be as follows:

Setting 100-pound base....................	0.0083 per pound
Setting 50-pound base....................	0.0165 per pound
Setting 40-pound base....................	0.0065 per pound
Average for the three....................	0.0101 per pound

It is hardly practicable to set up a table giving the unit times required for all of the different items of cast iron that might be used, but the information just given should enable you to figure the cost as closely as necessity warrants.

The time necessary for setting those items of iron-work that are placed by carpenters and which require boring and lag-bolting can be computed from Table 70, by figuring the time necessary to do all the boring required and adding 1½ times that amount to cover the cost of bolting and assembling.

SECTION IV. HOUSE CONSTRUCTION

The work of framing and erecting the timber portions of houses and similar buildings is usually a very simple operation, practically the only items involving any complicated work are stairs, bay-windows, roofs and dormers.

Because house framing is so simple, the most usual method is to compare the building being estimated with some previous job, and then assume a comparative cost per thousand feet board-measure for the new work. This method is usually very satisfactory but sometimes apparently slight variations in the framing will make disproportionately large increases in the cost.

For this reason the same analytical method as outlined for mill-construction should be used to determine the unit-prices which will be used in a house-construction estimate for the framing, using the data in Table 73, while for the erection the data given in Table 76 should be used.

It should be noted that the times given in Table 73 are for spruce, hemlock or other soft wood and they should be increased as follows if hardwood framing timber is used:

For hard pine add 20 per cent to tabular time
For chestnut add 25 per cent to tabular time
For oak add 30 per cent to tabular time

TABLE 73.—HOUSE FRAMING

(Time in carpenter hours per 100 pieces)

Joists	Fire-cutting (hours)	Square-cutting (hours)
2 by 8	16	14
2 by 10	18	16
2 by 12	24	22
3 by 10	25	22
3 by 12	30	27
3 by 14	35	32
Rafters	**Main rafters**	**Jack and cripple rafters**
2 by 6	14	18
2 by 8	16	20
2 by 10	18	22
Wall studs, plates same	**Cutting both ends and notch for ribbon**	**Halving for splices, add**
2 by 4	10	3
2 by 6	12	4

TABLE 73.—HOUSE FRAMING.—(*Continued*)

Partition studs, caps and sills same	Cutting both ends
2 by 3	7
2 by 4	8
2 by 6	9
Main sills, halving only	
4 by 6	50
6 by 6	75
6 by 8	100
Hips and valleys, 1½ times adjoining rafters	
Bridging	2

TABLE 74.—HOUSE FRAMING

(Average number hours carpenters' time per 1,000 feet board measure)

Joists		Fire cutting	Square cutting	Notching
2 × 8	10 feet	9	8	11
	12	8	7	10
	14	7	7	10
	16	6	6	9
2 × 10	12 feet	9	8	11
	14	8	7	10
	16	7	6	10
	18	6	6	9
2 × 12	14 feet	12	11	14
	16	10	9	13
	18	8	7	10
	20	7	7	10
	22	7	6	9
3 × 10	14 feet	13	12	15
	16	11	10	14
	18	9	8	11
	20	8	7	10
	22	8	7	10
3 × 12	14 feet	16	15	20
	16	14	13	16
	18	12	11	14
	20	10	9	13
	22	10	9	13
	24	9	8	11
3 × 14	16 feet	17	16	20
	18	14	13	16
	20	12	11	14
	22	12	11	14
	24	10	9	13

NOTE.—Common rafters take same time as fire cutting joists of same size. Jack and cripple rafters take 1.3 × time for fire cutting. Hips and valleys take 2.0 × time for fire cutting.

TABLE 75.—STUD PARTITIONS

Studs	Spacing, inches	Height, feet	FBM per 100 linear feet[1]	Average carpenter hours per 100 linear feet[2]
2 × 4	12	8	799	12
		10	934	13
		12	1,067	14
	16	8	667	10
		10	767	11
		12	867	12
2 × 6	12	8	1,200	19
		10	1,400	22
		12	1,600	25
		14	1,900	30
	16	8	1,000	16
		10	1,150	19
		12	1,300	21
		14	1,550	25

[1] Includes studs, sill, plate, and bridging.

[2] Includes erecting in buildings 1 to 4 stories high. If studs are cut on power saw, multiply time × 0.70 and add cost of saw at 3 hours per 1,000 feet board measure.

In using Table 73, note particularly that the cost of framing a stick is really independent of the length of the stick, so the cost of 1,000 FBM will increase as the length of the pieces decreases.

An example of the working out of this point is as follows: Assuming a carpenters' wage rate of \$1.12½ per hour the cost of framing 2 by 6 rafters would be

	Pieces per 1,000
\$26.30 per 1,000 for 6-foot lengths..........	167
13.15 per 1,000 for 12-foot lengths.........	84
11.34 per 1,000 for 14-foot lengths.........	72
9.92 per 1,000 for 16-foot lengths.........	63

It can readily be seen that the use of this method eliminates the necessity of guessing how much should be added to the estimate for dormers, bay-windows, and similar features involving a great number of short sticks, since by counting the number of individual pieces required, and figuring the cost on that basis, we have made the necessary allowance in the labor column and need only extend the materials at the proper price into the materials column.

Table 76.—Erecting House Framing
(Time in carpenter hours per 1,000 FBM)

	Hours
Setting joists on masonry wall	9
Setting joists on main sill	11
Setting joists on girts or ribbons	12
Setting wall studs, including plates	7
Setting 2-story partition studs	7
Setting 1-story partition studs	11
Bridging joists	9
Bridging partitions	9
Setting ceiling beams	12
Setting main rafters	12
Setting jack and cripple rafters	17
Setting hips and valleys	17

In most cases it will be practicable to substitute from one-fourth to one-third of laborers' time for the carpenters' time given above, since a great deal of the work consists merely of handling and passing the lumber to the carpenters.

TABLE 77.—HOUSE FRAMING TIMBERS

(Feet board measure per stick)

Sizes	Lengths (feet)								Any length
	10	12	14	16	18	20	22	24	
2 × 4	6.7	8	9.4	10.7	12	13.4	14.7	16	L[1] × 0.667
2 × 6	10	12	14	16	18	20	22	24	1.0
2 × 8	13.4	16	18.7	21.4	24	26.7	29.4	32	1.333
2 × 10	16.4	20	23.4	26.7	30	33.4	36.7	40	1.667
2 × 12	20	24	28	32	36	40	44	48	2.0
2 × 14	23.4	28	32.7	37.4	42	46.7	51.4	56	2.333
3 × 4	10	12	14	16	18	20	22	24	1.0
3 × 6	15	18	21	24	27	30	33	36	1.5
3 × 8	20	24	28	32	36	40	44	48	2.0
3 × 10	25	30	35	40	45	50	55	60	2.5
3 × 12	30	36	42	48	54	60	66	72	3.0
3 × 14	35	42	49	56	63	70	77	84	3.5
4 × 4	13.4	16	18.7	21.4	24	26.7	29.4	32	1.333
4 × 6	20	24	28	32	36	40	44	48	2.0
4 × 8	26.7	32	37.4	42.7	48	53.4	58.7	64	2.67
4 × 10	33.4	40	46.7	53.4	60	66.7	73.4	80	3.333
4 × 12	40	48	56	64	72	80	88	96	4.0
4 × 14	46.7	56	65.3	74.7	84	93.3	102.7	112	4.67

[1] L = length in feet.

Table 78.—Lengths of Rafters and Areas of Pitched Roofs

Nominal pitch	Rise, inches per foot	Rafter length		Hip or valley	Area
		$L \times$	$W \times$	$L \times$	$A \times$
¼	6	1.12	0.56	1.53	1.12
⅓	8	1.20	0.60	1.59	1.20
⅜	9	1.25	0.63	1.63	1.25
½	12	1.42	0.71	1.76	1.42
⅝	15	1.60	0.80	1.91	1.60
¾	18	1.80	0.90	2.09	1.80

Note.—W = width of building over plates, or over cornice if rafters extend into cornice.

$L = \frac{1}{2}W$

A = product of horizontal dimensions. This applies whether roof is gabled, hipped, or otherwise arranged.

Table 79.—High Scaffolds

(For interiors of churches, theaters, etc.)

For each 12 feet of height, allow 0.4 FBM per square feet of area covered.

For each square feet of floor area covered, allow 2.0 FBM plank.

Figure 50 per cent salvage.

Figure 16 hours carpenter labor per 1,000 FBM for erecting.

Figure 3 hours laborers' time per 1,000 FBM for dismantling.

The figures given in this chapter are for all hand work and do not include anything for the time of a foreman in laying out cuts. It is assumed that a template will be made in each instance where there is an appreciable number of sticks to be cut to the same pattern and the figures are based accordingly.

Where other than square-end cuts, or fire-cuts, are required, the time for laying out a cut may be as high as half the time required for making the cut but, with a template, this cost

should be distributed over so many pieces that the charge per stick is negligible.

Machine Work.—It is not possible to give as much data as desirable on the use of power saws and power drills. It is quite doubtful that the old types of power saws, requiring fixed locations, would show any economy at all on small sized jobs, and on large jobs their economy is entirely a matter of organizing the work so that the cost of handling the stock to and from the machine does not eat up any possible saving due to the use of the machine.

On the other hand, with the many types of portable equipment now available, appreciable savings can be made, though it is seldom that the savings will equal the optimistic claims of their manufacturers or dealers.

Making proper allowances for the current required for operation, changing wiring and other incidental expenses, it is safe to figure that the cost of work done with portable power tools of proper size and design will not exceed 70 per cent of the cost of straight hand work.

Therefore, when figuring on the use of a power saw or drill, the time given for hand work should be multiplied by 0.70 to get the time in hours of the men using the machines and performing the same operations.

CHAPTER VIII

BOARDING, PLANKING, SHINGLING

SECTION I. PLANKING

While 1,000 FBM is undoubtedly the proper unit to use in calculating the quantities of materials required for all such items as floor and roof-planking, flooring, siding, sheathing, etc., the square, or 100 square feet, is the handiest unit to use when figuring the labor cost, and that unit has been used in all cases in this chapter.

In figuring the cost of the material necessary to lay a given area of planking, or boarding, due allowance must be made for the waste due to matching, cutting of ends, cutting out bad spots, etc.

If the planks for any piece of work can be ordered directly from the mill and if the spacing between supports is uniform, it is often possible to purchase plank so that practically the only waste will be that due to matching.

However, materials purchased from yard stocks are always subject to an over-run of 5 per cent, and due allowance must be made for this over-run when estimating. For instance, in a factory which required 100,000 FBM of floor and roof planking, all might be needed in 20-foot lengths.

If plank were ordered from a yard that did not have enough 20-foot pieces and added 21- or 22-foot pieces to make up the quantity, the purchaser would have to pay for that useless over-length up to a total of 5,000 FBM. Therefore, when estimating, be sure to determine whether stock will have to be purchased from yards and make allowance accordingly.

Side-waste, from matching, is a very uncertain quantity in planking, since it varies with the width of the plank. If it is known in advance that it is possible to get all planks

of a given width, one could estimate accordingly, but the increase in price when all plank of one width are specifed will usually over-balance any possible saving.

Since matching usually takes ¾-inch from the width of a plank, it is evident that the percentage of side waste must be as follows:

	Per Cent
4-inch wide planks......................	18¾
6-inch wide planks......................	12½
8-inch wide planks......................	9⅜

An ordinary lot of random width floor or roof plank will not average over 6 inches wide, so it is well to allow at least 12½ per cent for the side waste.

If the distances between supports are not uniform, or, if those distances are not such that readily obtainable lengths of plank can be used, then additional allowance must be made for end-waste on that account.

In most markets, planks are usually available in lengths varying by multiples of 2 feet, from 12 feet upward. This means that, no matter what the actual length of plank required, the user must buy and pay for planks of the next larger length in even feet.

Thus, for an actual length of, say 18 feet 4 inches, he would have to buy 20-foot planks and waste the difference, or 9.3 per cent.

Adding this end-waste of 9.3 per cent to a side waste of 12.5 per cent we would have a total waste of 21.8 per cent or practically 22 per cent, which must be added to the estimate.

When splines are used, which is seldom the case with plank of a nominal thickness less than four inches, their cost is determined by allowing one foot of spline for each linear foot of plank.

Thus, if the plank average 4 inches wide, the total linear feet of splines will be three times the total area of planking; if 6 inches wide, twice the area; if 8 inches wide, one and a half times the area, and so on.

Various tables have been published for computing the quantities of nails or spikes required for floor and roof-planking, but most of these tables give quantities very much smaller than will actually be used.

Ordinarily, spikes used in planking should not be much shorter than ½ inch less than twice the nominal thickness of the plank, thus:

For 4-inch plank use 7-inch spikes, figure 9 to the pound.
For 3-inch plank use 60d spikes (6 inches long) figure 12 to the pound, or
For 3-inch plank use 50d spikes (5½ inches long) figure 15 to the pound.
For 2-inch plank use 16d spikes (3½ inches long) figure 51 to the pound.

The number required will be determined by allowing 2 nails, or spikes, for each plank on each bearing. Thus planks 6 inches wide, 20 feet long, on 10-foot bearings, would require 6 nails per plank or 0.6 nails per square foot or 60 nails per square.

On this basis the quantities would be as follows:

TABLE 80.—NAILS REQUIRED

		Per square, pounds	Per 1,000 FBM, pounds
4-inch plank.........	6-foot supports	11.2	28
	8-foot supports	8.4	21
	10-foot supports	6.7	17
	12-foot supports	5.6	14
3-inch plank.........	6-foot supports	8.4	28
	8-foot supports	6.2	21
	10-foot supports	5.0	17
2-inch plank.........	4-foot supports	2.8	14
	6-foot supports	2.0	10
	8-foot supports	1.4	7
	10-foot supports	1.1	6

These are the actual quantities required but, because of the many wastes that occur on every job, it is always well to allow an increase of 50 per cent of the computed quantities when estimating.

Whenever the conditions are such that the planks can be ordered of a very few lengths, that will work without further cutting, it is well to buy them "butted to exact length."

Dealers usually make an extra charge for butting but their charge is usually small as compared with the cost of butting on the job, even though power-saws are available.

Having figured the cost of landing the planks at the level at which they are to be laid, as previously explained, we now have only to figure the cost of placing, including the setting in of splines, when specified, and the cost of spiking.

The cost of placing plank, because of the inconvenience in working and moving around, naturally increases as the plank-span increases. On the other hand, since the number of nails per bearing is usually the same, the cost of nailing or spiking increases as the distance between bearings decreases.

For all practical purposes, therefore, the same cost may be figured for all reasonable variations in plank-span length.

TABLE 81.—LABOR HOURS PER 100 SQUARE FEET

Nominal thickness, inches	Tongue and grooved	Splined	Laminated
2	3		
3	3.5	4.5	
4	. . .	5	7
5	. . .	5.5	8
6	. . .	6	9

The column for splined plank includes the time necessary for placing the splines.

The time in Table 81 is given entirely in labor hours because local conditions will determine what portion of the work can advantageously be done by laborers and what portion must be done by carpenters. Beyond the butting of the plank, however, there is really very little work connected with the laying of plank that requires the skill of the carpenter.

SECTION II. FLOORING, BOARDING, SHEATHING

In the previous discussion of the cost of timber-framing, you have become familiar with the cost of transporting lumber to the site of the work and of placing it on the level at which it is to be used, and no repetition is necessary here.

The same general principles apply to the application of flooring, boarding, sheathing, ceiling, etc., as apply to the laying of floor and roof-planking, but in these present items a greater number of factors affect the amount of waste involved and the amount and quality of the labor required.

If we always knew in advance that our lumber would be as good as we expect it to be, and our architects no more exacting than we read their specifications to be, it is probable that we could figure upon a less proportion of waste material and a greater production per man-hour.

Under present market conditions, and with present grading rules, we are always likely to have to do a great deal of cutting out and rejecting, which means waste of material and added cost for labor.

In preparing the following tables, all of these conditions have been given consideration and allowance made accordingly. In figuring, it is assumed that the estimator will always consider small openings as part of the area to be covered, making no allowance for the saving and, in the cases of irregular or badly broken-up areas, he will make a judicious addition to the figured allowances for labor and for waste material.

TABLE 82.—FLOORING, SHEATHING, ETC.
(Carpenter hours per 100 square feet)

	Time	Add percentage of waste required	Nails, pounds
3¼ face NC or fir flooring.	2.8	15	4.5 (on underfloor)
2¼ face NC or fir flooring.	3.0	30	5.5 (on underfloor)
3¼ face NC or fir flooring.	3.3	20	4.5 (on joists)
2¼ face NC or fir flooring.	2.5	30	5.5 (on joists)
2¼ face oak............	3.0	30	5.5 (on underfloor)
2¼ face beech, birch or maple	2.8	30	5.5 (on underfloor)
1 × 6 underfloor on joists.	1.7	15	2.0
1 × 8 underfloor on joists.	1.5	15	1.7
1 × 6 underfloor on joists.	2.2	25	2.0 diagonal
1 × 8 underfloor on joists.	2.0	25	1.7 diagonal
1 × 6 roofers on sidewall studs..................	2.4	15	2.0
1 × 8 roofers on sidewall studs..................	2.2	15	1.7
*1 × 6 roofers on flat roof.	2.2	15	2.0
*1 × 8 roofers on flat roof.	2.4	15	1.7
*1 × 6 roofers on pitched roof..................	2.6	25	2.2*
*1 × 8 roofers on pitched roof..................	2.8	25	1.9*
Narrow ceiling on sidewalls	3.5	25	2.0
Narrow ceiling on ceiling..	4.0	25	2.0
Narrow clapboards on walls	4.0	25	2.0
Wide clapboards on walls.	2.5	25	1.6

* Add 1 hour to total figures for each 10 linear feet of hips, valley and ridges in the roof and 1½ feet BM waste lumber for each linear foot of hip, valley and ridge.

SECTION III. SHINGLING

While the square seems to be the most convenient unit for use in figuring the items just discussed, shingles can better be figured by the thousand.

This is true because, even though the number of squares must be taken off the plan in order to compute the quantity of shingles required, it takes just as much labor to lay a thousand shingles with a 4-inch exposure to the weather as with a 5-inch exposure, the area covered will be materially less.

Shingles, as delivered, vary in width but are counted on the basis of 4 inches wide, so the actual number of pieces in a bundle is immaterial but the charge is for a quarter-thousand.

Shingles are usually made 16 or 18 inches long but, since the exposure to the weather is what governs the quantity used, the length makes no difference in the number required but will make a difference in the cost, because the 18-inch shingles cost more per thousand.

Also, because of the greater lap afforded they make a warmer house.

Shingles on roofs are usually laid 4, 4½ or 5 inches to the weather, on sidewalls they may have as much as 10-inch exposure and sometimes are laid with the courses alternating, first a course of narrow exposure, then one of wide exposure.

Since the shingles average 4 inches in width, when laid 4½ inches to the weather, each shingle covers 18 square inches and 8 shingles cover one square foot. Upon this basis we may calculate our table as below.

The usual method of figuring the labor, as given in most handbooks, is to take a certain figure for "plain roofs" and another one for "fancy roofs," but that hardly seems definite enough, so the following method is recommended.

To these figures it is necessary to add 10 minutes time for each linear foot of door- or window-casing or similar trim against which the shingles must be fitted, and also 20 minutes time for each linear foot of ridge hip or valley.

TABLE 83.—SHINGLES REQUIRED PER 100 SQUARE FEET

Exposure, inches	Number required	Nails required, pounds
4	900	3.9
4½	800	3.5
5	720	3.3
6	600	2.7
7	515	2.3
8	450	2.0
9	400	1.8
10	360	1.6

TABLE 84.—LABOR PER 1,000 SHINGLES

	Hours, carpenter time
On straight roofs	3.5
On curved surfaces	5.0
On side walls	4.0

With these additions, the tabular figures will be large enough to cover erecting and taking down the usual amount of scaffolding.

With the great variety of asphalt, and other forms of proprietary shingles that are now on the market, it is hardly practicable to prepare a table that would cover them all, but the following figures will prove helpful.

TABLE 85.—LABOR PER 100 SQUARE FEET

	Hours, carpenter time
Asphalt strip shingles	2
Asphalt twin shingles	2.25
Asphalt single shingles	2.75

SECTION IV. FURRING AND GROUNDS

No attempt will be made here to discuss the cost of affixing the many kinds of patented furrings and "spot" grounds. The manufacturers of most of such articles have collected data on their cost of installation and are glad to furnish information at any time. When using such information, however, it is necessary to be sure that it is in such form that it can be applied to the problem in hand.

Some strip furring is figured by the square, which is all right if the proper allowances are made for waste, etc., but, since furring is often sold on the basis of the number of linear feet, I recommend that method of figuring.

Knowing the spacing, it is a simple matter to calculate the number of linear feet required, and then an allowance of at least 10 per cent should be added to cover end-waste on strips, short pieces, cross strips, etc.

The labor can readily be figured by means of Table 86.

TABLE 86.—FURRING
(Carpenters' time per 1,000 linear feet)

	On joists	On T. C. tile	On gypsum tile	On brick
1 by 2........	7	11	10	13
2 by 2........	8	13	12	15
2 by 3........	8.5	14	13	17

The figures for furring on brick are based upon the assumption that plugs have already been placed in the wall. If wood plugs must be inserted, add 6 hours to the figures given in the table.

The item of grounds affords more opportunities of guesswork than almost any other item in the carpenter's estimate. This is true because few people take the time to compute the quantities required or make any actual effort to find what it really costs to affix grounds.

Care should be taken to include grounds for every kind of wood trim that is to be attached in plastered rooms and

to study the detailed drawings carefully to find out just how much grounding is necessary.

Ordinarily, the following figures should be used:

Base, 2 linear feet grounds per linear foot.
Chair rail, 2 linear feet grounds per linear foot.
Picture-mould, 1 linear foot grounds per linear foot.
Casings, 1 linear foot grounds per linear foot.

The labor may be calculated from Table 87.

Table 87.—Grounds

(Carpenters' time per 100 linear feet)

	Hours
On brick	5
On terra cotta	4.5
On gypsum	4.5
On wood	4

If plugging of brick walls must be done, then the same allowances must be made as for furring.

CHAPTER IX

FINISHED CARPENTER WORK

SECTION I. GENERAL INSTRUCTIONS

It is hardly within the province of this chapter to attempt to give a detailed explanation of the method of figuring the cost of mill-work materials, since that is the manufacturer's job rather than the construction estimator's, but it will be in order to suggest the methods to be used in taking off quantities and securing prices.

If the materials required are all of stock sizes and patterns, it is a simple matter to make a complete list of the items required, price them from a catalogue and discount sheet, or send the list to dealers and have them quote on it.

If the material is only partly of stock patterns, part of it can be priced from the catalogue as above, or all of it sent out for prices, but if the patterns are at all unusual, it is always best to have the mill-estimator take his own quantities directly from the plans.

When sending out lists for prices, it is well to transcribe all those parts of the specifications that describe the kind, size or quality of members required. Also note carefully every given dimension of all of the different members required.

For instance; window-frames should have dimensions given for outside-casing, pulley-stile, head-casing (also whether square- or segment-head), parting, beads, sills, etc., also complete description of pulleys if any are to be installed.

Sash should have dimensions given for thickness and width of stiles and rails, kind of glass and number of lights.

Doors should be completely described by size, thickness, number of panels and material and, if possible, accompanied by sketch.

Window-trim should have dimensions and descriptions of inside-casings, head-casings, stops, stools, aprons, also false-jambs, back-bands, scotia, etc., if required.

There are many methods of procedure used in taking off and listing the quantities but the one that is simplest and most readily checked is as follows:

After having made all of the notes referred to above, make headings, thus:

Basement:
  Door frames,
  Window frames,
  Doors,
  Sash,
  Stair-treads,
  (other items, if any)

after each heading, put down the number and size of each required, then proceed with the

First Floor:
  Door frames,
  Window frames,
  Doors, exterior,
  Doors, interior,
  Sash,
  Door jambs,
  Door trim,
  Window trim,
  Base,
  Chair-rail,
  Picture mould,
  Beam-casings,
  Beam soffits,
  Stair-rail,
  Balusters,
  Newels,
  Treads,
  Risers,
  Etc., etc.

Door- and window-trim is listed by writing down the number of "sides" required. A "side" consists of a complete set of material necessary to trim one side of an opening; thus, an inside door requires two sides of trim, while an outside door or a window requires only one side. Door jambs are listed by the "set."

If the description previously mentioned is given, any mill-estimator will be able to calculate the cost of a side of door-trim or a side of window-trim and will quote accordingly.

Because of the allowances that must be made for waste, few mills will make any difference in the price of a side of trim for a 2 feet 6 inches by 6 feet 6 inches door and one for a 2 feet 0 inches by 7 feet 0 inches door. In fact, unless you ordered the casings cut to length and made up in "cabinet-trim" you would probably receive them in 7-foot or 14-foot lengths, where mitering is not required and 16-foot lengths if the trim is to be mitered at the head.

Where the builder is willing to take the extra trouble incurred in handling the materials at the work, he can often buy his mill-work more cheaply by simply ordering a sufficient number of linear feet of casings, stops, plinth, back-bands, window-stools, etc.

Stairs, pantries, cupboards and mantels should be fully described and sketches sent whenever possible.

For approximate estimating, the simplest method is to price frames, doors and sash from catalogues, then if the items are such that they cannot readily be priced in that way, calculate each member into "moulding-inches" and price it at the prevailing price per 100 linear feet per "moulding-inch."

A moulding-inch is the equivalent of a piece 1 inch square and 1 foot long, and is figured upon the basis of the full size of stock from which the moulding must be made.

Get the prices for different woods from a reliable mill and calculate the quantities by multiplying the dimensions of each member thus: a ¾ by 4¾ casing must be cut from a

1 by 5 board, therefore, it equals 5 moulding-inches. Follow this method through for each member.

When listing mill-work be careful to note whether any priming-coat is to be applied or if any back-painting is to be done at the shop and, when ordering, be sure that no priming-coat is put on any surfaces which are to be stained instead of painted.

SECTION II. INTERIOR WORK

You are now ready to attack the labor estimate, and can use the following figures in computing the cost.

TABLE 88.—INTERIOR WOOD-WORK
(Hours carpenter time per 100 linear feet)

	Soft wood	Hard pine	Oak	Mahogany or gum
Base	4.5	5.7	6.2	6.8
Base-mould	1.7	2.1	2.4	2.6
Floor-mould	1.5	1.9	2.1	2.3
Chair-rail	4.0	5.0	5.5	6.0
Wainscot-cap	3.8	4.8	5.3	5.8
Picture mould	3.5	4.4	4.8	5.4
Beam-casings	4.5	5.7	6.2	6.8
Beam soffits	4.5	5.7	6.2	6.8
Beam cornice[1]	5.0	6.3	6.9	7.5
Panel stiles[1]	7.0	8.8	9.7	10.5
Panel mouldings[1]	7.0	8.8	9.7	10.5
Plate rail	6.5	8.1	9.0	9.8
Plate rail-apron	6.5	8.1	9.0	9.8

NOTE.—To obtain these results, one laborer will be required for each four carpenters; therefore, an allowance of 1 hour of laborers' time should be added for each four hours of carpenters' time.

[1] Add 5 minutes for each miter required.

TABLE 89.—DOORS AND WINDOWS AND TRIM

(Hours per single opening 3 feet 0 by 7 feet 0 or less)

	Soft woods	Hard pine	Oak	Mahogany or gum
Fit sash	2.0	2.5	3.0	
Attach weights and cord	1.0	1.0	1.0	
Attach weights and chain	1.25	1.25	1.25	
Attach sash fasts	0.2	0.2	0.2	
Attach flush lifts	0.3	0.4	0.4	
Attach bar lifts	0.2	0.2	0.2	
Attach pole socket	0.2	0.2	0.2	
Install stops with adjusters	0.5	0.5	0.5	0.7
Install stops with screws	0.4	0.4	0.4	0.6
Install false jambs	1.5	2.0	2.2	3.0
Install casing, stool and apron	2.0	2.5	2.5	3.0
Fit door	2.0	1.5	1.8	2.0
Attach butts (per pair)	0.6	0.8	0.9	1.2
Attach spring butts	1.5	1.7	1.8	2.5
Attach floor hinge	2.0	2.2	2.5	3.0
Attach flush bolts	1.0	1.2	1.5	2.0
Attach cremorne bolts	1.5	1.7	1.8	2.5
Set jambs	0.5	0.5	0.8	0.8
Plant on stops	0.8	0.8	0.9	1.3
Set casings	2.5	2.9	3.5	3.9
Set back bands	1.0	1.2	1.5	2.0
Set plinths	1.0	1.2	1.5	2.0
Add for mitered heads	0.5	0.5	0.6	1.0
Set cap mould	0.5	0.5	0.5	1.0
Attach mortise lock	1.0	1.2	1.5	2.5
Set transom	1.5	1.7	1.8	2.5
Install transom catch	0.6	0.8	0.9	1.2
Install transom operator	1.0	1.2	1.5	2.0

NOTE.—The same addition must be made for laborers' time as in Table 88.

The amount of time indicated in these tables, for the several kinds of work, is sufficient to cover all direct labor

from the time the materials are delivered inside of the building.

It requires practically as long to perform the work on a smaller opening as it does on one up to 3 feet 0 inches by 7 feet 0 inches, but, when the openings are larger, the weight of the materials to be handled becomes so great and the amount of work to be done is so much that the time allowances must be increased proportionately.

TABLE 90.—STAIR-WORK

(Hours of carpenters' time)

	Soft woods	Hard pine	Oak	Mahogany or gum
Housing out stringers (per tread and riser)	0.5	0.6	0.7	0.9
Fitting plain rabbeted treads	0.3	0.4	0.5	0.8
Fitting plain plowed risers	0.3	0.4	0.5	0.8
Cutting open stringers (per tread and riser)	0.4	0.5	0.6	0.8
Miter return on end of open stairs treads	0.3	0.4	0.5	0.7
Placing scotia, per 100 feet	2.5	3.0	3.5	4.5
Placing skirt mould, per 100 feet	3.0	3.5	4.0	5.0
Placing skirt board, per 100 feet	5.5	6.7	7.2	7.8
Placing baluster rail, each 10 feet	3.0	3.0	3.5	4.0
Placing wall rail, each 10 feet	1.0	1.0	1.5	2.0
Placing balusters each	0.1	0.1	0.1	0.2
Setting newels each	1.0	1.0	1.5	2.0

NOTE.—Figure all rough carriages for stairs, also all rough stairs, such as are sometimes used for cellar stairs, according to the method delineated for timber-framing, but be sure to make allowances for each carriage, or stringer, each tread and each riser and necessary cuts.

One hour of laborers' time should be added for each 8 hours of carpenters' time on stair-work. Because of the nature of the work, the mechanics do not handle as great a volume of material as when on other forms of interior wood-work, so a smaller number of laborers may be employed than on trim.

TABLE 91.—MISCELLANEOUS INTERIOR WOOD-WORK
(Hours of carpenters' time)

	Soft woods	Hard pine	Oak	Mahogany or gum
Placing 4-ft. high "made-up" panelled wainscot, per 100 linear feet	15.0	15.0	17.0	21.0
Ditto 6 feet high	17.0	17.0	19.0	28.0
Ditto 8 feet high	19.0	19.0	21.0	30.0
Fitting and hanging cupboard doors	0.6	0.7	0.7	1.0
Setting drawer cases	1.5	1.5	1.5	2.0

It is obviously impracticable to list here all of the various fittings and fixtures that might be introduced under the heading of Interior Wood-work, but there are very few instances where the work to be done cannot be analyzed into its component operations and, having done that, the cost can be calculated from the information given in Tables 88 to 91.

Care must always be taken to see that sufficient grounds or blocking have been provided properly to secure all interior wood-work and all of those items should be included in the estimate under their proper headings, as previously explained.

Where the finish is specified to be hand-smoothed or "bench-sanded," the allowances included in Table 92 must

be included in the estimate. Be sure to include as many sides or edges of the member as are to be exposed.

TABLE 92.—SANDING INTERIOR FINISH

(Hours carpenters' time per 100 square feet)

	Plain	Moulded
Hard woods..........	1.25	1.50
Soft woods...........	1.00	1.25

NOTE.—Members under 6 inches wide should be counted as 6 inches and all wider than 6 inches should be counted as a foot wide, or when the actual width is greater than a foot, then their actual width. This is because it takes about as much time to handle a narrow piece as it does to handle a wide one.

Nails.—It would be futile to attempt to compile an accurate schedule to indicate the number of nails required for the various operations included in interior wood-work, but an allowance of 2 pounds of nails for each 100 linear feet of casing, stool, apron, mouldings, etc., will cover all that are actually used, as well as those that are usually wasted.

SECTION III. EXTERIOR WORK

TABLE 93.—EXTERIOR WOOD-WORK

(Hours of carpenters' time per 100 linear feet)

Box cornices, each member................	3.0
Open cornices, for each moulding cut between rafters..............................	5.0
Corner boards and water table.............	3.5
Placing false rafters (each)................	0.5
Placing porch posts.......................	2.0

NOTE.—The same allowances should be made for the extra cost of miters and for laborers, time as given in Table 89.

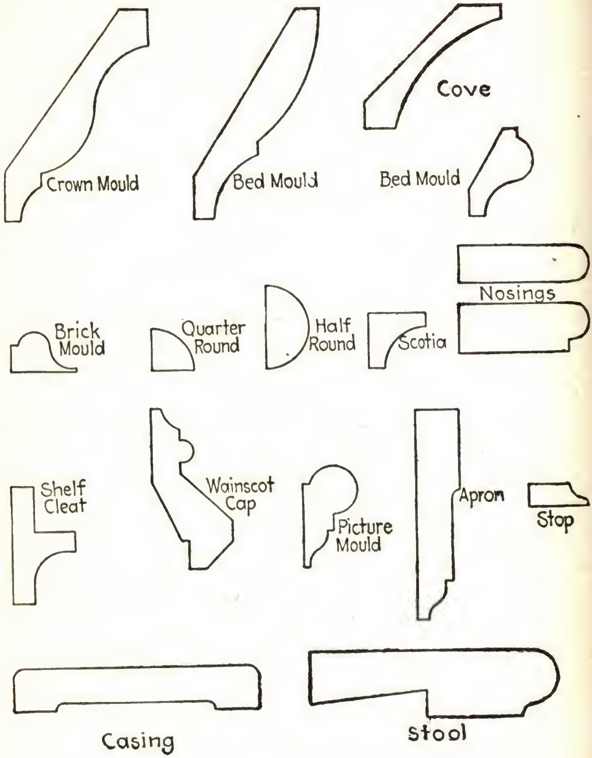

FIG. 19.—Standard wood mouldings.

TABLE 94.—DOOR AND WINDOW FRAMES
(Hours of carpenters' time per unit)

	Masonry wall	Stud wall
Setting single door frames	1.75	1.50
Setting double door frames	2.75	2.50
Setting single window frames	1.25	1.00
Setting double window frames	1.75	1.50
Setting triple window frames	2.75	2.50

These costs include necessary bracing, plumbing, attaching anchors, etc.

SECTION IV. WALL BOARD

Of late, there has come onto the market a great variety of wall boards, made from wood pulp, vegetable fibres or other by-products. Some of these are used principally for their insulating value, some for decorative value, and some merely because they are inexpensive.

Most such boards are made in 48-inch width and in lengths of 6, 7, 8, 8½, 9, 10 and 12 feet. This makes it practicable to apply the boards to either 12-inch or 16-inch spacing of studding and in one piece for the full height of a wainscot or wall with almost no cutting. This avoidance of cutting on the job is important, since the nature of the materials makes cutting with a saw slow, and it is extremely difficult to make neat cuts.

Joints are frequently covered with wood batten strips, or with batten strips of the same material as the boards, but cut in the factory to the proper width and sometimes chamfered.

The following figures will apply to almost any of these boards now on the market:

QUANTITY PER 100 SQUARE FEET

Weight of boards	60 pounds
Applying on 16-inch studding	4 hours
Applying on 12-inch studding	5 hours
Applying batten strips	4 hours per 100 linear feet

CHAPTER X

STRUCTURAL STEEL AND IRON WORK, STEEL SASH

SECTION I. STRUCTURAL STEEL

If this book were intended for the use of workers in structural steel and iron works, we should take up in detail the subject of the costs of the various items of shop-work that enter into the preparation of steel and iron-work for buildings.

This book, however, is intended primarily for the use of general contract estimators, and will therefore only cover those portions of the work handled by a builder.

Of course, on jobs involving a large tonnage of steel, the builder will prefer to sub-let the erection, either to the company furnishing the steel or to someone who specializes in steel-erection and who will have the necessary equipment of engines, derricks, riveting machinery, etc.

In estimating the cost of erection, the same care should be taken as when figuring to furnish the material, except that no count need be taken of shop-rivets, nor need any mention be made of such strictly shop-items as coping beams, etc.

Of course, in making a list of steel for pricing or purchase, it will be necessary to describe all punching, coping, shop-riveting, etc., to be done on each piece.

When listing for estimating, or for purchasing, keep the following facts in mind:

Wall-bearing beams always require steel or cast-iron bearing-plates under each end, and nearly always have an anchor of some sort as well.

Beams framing into other beams, or into girders, require connection angles and bolts, or rivets, at all connections.

Girders, lintels, grillages, and other members made up of more than one unit, require bolts and separators to hold them in proper assembly.

Trusses are often shipped in sections and, therefore, require bolting up in the field.

Even though seldom indicated on small scale plans, trusses usually require gusset plates at the connections between the several members.

Many of the items mentioned here are frequently omitted from the drawings but are covered by some general clause in the specifications that requires the contractor to furnish everything necessary to make a complete job. This is manifestly unfair, but since contractors continue to bid for and accept work on that basis, it is a condition with which we must contend.

When no sizes are given for these various sundries, the estimator must assume that they are the standard sizes for the conditions. Every estimator who has frequent occasion to figure on steel work should, therefore, provide himself with a copy of some such handbook as that issued by Carnegie or Cambria Steel Company, which gives complete data on all standard construction.

When listing steel for purchase, the items should be set down in some such manner as follows:

STEEL FOR JONES BLOCK, BONDSVILLE, MASS.

First story:

Three 12-inch 31.8-pound I-beams, 19 feet 8 inches long. (Wall bearing.)

Five 10-inch 25.0-pound I-beams, 19 feet 8 inches long. (Wall bearing.)

Six standard bearing plates for 12-inch 31.8-pound I-beams.

Ten standard bearing plates for 10 inch 25-pound I-beams.

Ten lintels, each consisting of

Three 4 by 4 by ⅜ angles 5 feet 8 inches long, loose.

Five lintels, each consisting of

Two 10-inch 15-pound channels 8 feet 8 inches long.

Two standard separators for same.

Two 10 by 12 by ½ bearing plates.

Second story:

Six 10-inch 25-pound I-beams, 20 feet 4 inches long. (Wall bearing.)

Four 9-inch 21-pound I-beams, 8 feet 0 inches long. (Wall bearing. One end standard connection on other.)

Two 10-inch 25-pound I-beams, 20 feet 4 inches long. (Wall bearing, punched for connection of 9-inch 21-pound I-beam, 8 feet from each end.)

Ten lintels, each consisting of

Three 4 by 4 by 3/8 angles, 5 feet 8 inches long, loose.

Three lintels, each consisting of

Two 8-inch 11.25-pound channels, 8 feet 8 inches long.

Two separators for same.

Two 8 by 8 by 3/8 bearing plates.

Such a list would give a practical steel man a fair picture of what was required, but if used in taking off steel quantities from a large set of plans, for the purpose of figuring erection only, quite a bit of time would be consumed just in writing down items.

For figuring erection, the following method is as complete as needed, and gives the same results.

First floor beams,

(3) by 19 feet 8 inches by 31.8 pounds.
(5) by 19 feet 8 inches by 25.0 pounds.
Six bearing plates at 31.0 pounds.
Ten bearing plates at 17.0 pounds.

Lintels,

(30) by 5 feet 8 inches by 9.8 pounds.
(10) by 8 feet 8 inches by 15.0 pounds.
Ten separators, including bolts at 8.1 pounds.
Ten bearing plates at 17 pounds.

Second story beams,

(8) by 20 feet 4 inches by 25.0 pounds.
(4) by 8 feet by 21.0 pounds.
Twenty bearing plates at 17 pounds.
Four connections at 13 pounds.

Lintels,

(30) by 5 feet 8 inches by 9.8 pounds.
(6) by 8 feet 8 inches by 11.25 pounds.
Six separators at 5.9 pounds.
Six bearing plates at 6.8 pounds.

Field bolts,

Second floor, 4 connections at 4 = 16 bolts.

If preferred, the parentheses and multiplication signs may be omitted and quantities tabulated thus:

Name	Number	Length,		Weight per foot, pounds	Total
		Feet	Inches		
Beams...........	8	20	4	25	4,066
Beams...........	4	8	0	21	672
Bearing plates.....	20	..	..	17 (each)	340
Connections.......	4	..	..	13 (each)	52

And this affords an opportunity to note that of a total weight of only 5,130 pounds, 392 pounds, or practically 8 per cent of the total, is in items that are often omitted from the plans but which must be purchased and installed by the contractor. Some estimators make a practice of only listing the members shown and then allowing 10 or 15 per cent for sundries.

After calculating the weight of material to be handled, it is necessary to figure the cost of getting it to the work, unless it is purchased for delivery at the site, and of erecting it in place.

Sizes of individual members, as well as facilities for handling, have such a marked effect upon the cost of handling that it is very difficult to set down general rules for estimating that would cover every case, but the data presented here are on the side of safety and may be used with confidence.

There is no reason why practically all of the steel work in wall-bearing buildings cannot be erected by ordinary laborers, when under competent supervision, except that union rules do not permit it. However, in many districts union rules are not effectually enforced and laborers do the erection.

It is important to know, when figuring on work of any size, whether it can be handled by laborers or not as the difference in wage rates will make an appreciable difference in the cost per ton.

Of course, setting up the derrick and similar work should always be done by a competent man.

When no crane is available at the point of unloading from cars, it will be necessary to set up a derrick to handle the steel, unless the amount to be handled is so small that it is thought advisable to handle it by some less convenient means, and proper allowance should be made for setting up and taking down this unloading derrick.

The actual hauling cost can be estimated from the information given in Chapter II.

Allowance must also be made for the cost of setting up and taking down the derrick used at the building, as well as for moving it, from time to time.

For such operations as erecting trusses over one-story buildings, heavy individual girders and similar members, a gin-pole is often preferable to a derrick.

Rivetting.—When pneumatic hammers are used to drive rivets, an allowance of at least 40 hours must be made for installing and removing the compressor and reservoir, and the hoisting-engineer will also receive additional pay at the rate of one-half his regular pay for taking care of the compressor.

TABLE 95.—MISCELLANEOUS OPERATIONS[1]

	Erect	Move 20 feet horizontally	Raise 2 stories vertically	Take down
Gin-pole	40	15	..	10
Guy-derrick	60	20	60	20
Breast-derrick	10	3	5	3

[1] (Time in man-hours. Where local conditions will permit, an average of 1 foreman, 1 tradesman and 3 laborers make a good gang; elsewhere figure 1 foreman to 4 tradesmen.)

TABLE 96.—UNLOADING, ERECTING STRUCTURAL STEEL

(Man-hours per ton)

	Unloading	Erecting
Wall-bearing beams.....	2	8
Skeleton construction...	2	6.5
Roof trusses............	2.5	14.0
Roof purlins............	2.5	16.0

TABLE 97.—RIVETTING AND BOLTING

(Man hours per 100 units)

	Bolts	Hand driven rivets	Air driven rivets
Wall bearing construction.........	5		
Trusses and purlins..............	7	17	9
Skeleton construction............	7	13	7

TABLE 98.—AREA OF STRUCTURAL STEEL

(Approximate number of square feet of surface per ton of steel)

Floor beams, etc..........................	250
Heavy girders and columns................	200
Trusses and purlins.......................	400

TABLE 99.—PAINTING STRUCTURAL STEEL

	Gallons paint per coat per ton	Hours time per coat per ton
Floor beams, etc................	0.5	1.0
Heavy girders and columns.......	0.4	0.8
Trusses and purlins.............	0.8	1.6

Using the figures given in the tables, an average skeleton framed building, having 200 tons of structural steel, on eight tiers, would figure out as follows:

The gang is assumed to consist of

1 foreman	$1.50	
1 engineer ($1\frac{1}{2} \times$ $1.33 rate)	2.00	
4 ironworkers @ $1.00	4.00	
Total	$7.50 per hour or	
Average	$1.25 per man-hour.	

	Hours		
From Table 96			
Unload 200 tons @ 2 hours	400		
Erect 200 tons @ 6.5 hours	1,300		
From Table 95			
Set up derrick	60		
Lift three times	180		
Take down	20		
Set up and take down derrick at freight yard	80		
From Table 97			
10,000 air driven rivets @ 7 hours per 100	700		
Total	2,740	hours @ $1.25	$3,425.00
Compensation insurance....8 per cent			274.00
Hauling, 2 miles on hard road, 5-ton truck $2 \times 9 \times 0.75 = 13.5$ hours @ $3.50			47.25
Insurance on hauling @ 3 per cent			1.42
Allowing for rainy days and other delays, approximately 45 days will be required for the work. Allowing $10.00 per day for fixed charges on equipment, fuel and lubricants			450.00
Moving equipment to and from job			50.00
Total for 200 tons			$4,247.61
Average cost per ton			$ 21.24,

to which must be added general supervision, overhead and profit in order to determine the rate to be charged.

The number of rivets was assumed in this instance, in actual practice it should always be determined carefully from the plans.

Since it is quite customary to include the field coats of paint on structural steel in the erection sub-contract, it is necessary to make a figure on that item also.

As one-half gallon of paint and 1 hour of painters' time (skilled painters are not generally employed for this work, handy men being used) will be required for each 250 square feet of surface, per coat, the cost per ton will be as follows:

1 hour painter	\$0.60
½ gallon paint @ \$1.50	0.75
Cost per 250 square feet	\$1.35 or
Per ton for heavy girders, etc	\$1.18
Floor-beams, etc	\$1.35
Trusses and purlins	\$2.16

Welding.—Arc welding of structural steel is rapidly coming into use and it is, therefore, essential that an estimator should have some knowledge of the procedure to use in estimating its cost.

Naturally, though the tonnage to be handled in a welded frame will be considerably less than that required for a rivetted frame for the same sized building, the cost of actual erection will be practically the same per ton in either case.

Steel for welded frames is not generally painted at the shop and it is, therefore, necessary that two field coats be applied. The method of estimating painting is as outlined above, due allowance being made for the additional field coat.

In a welded job, instead of counting the rivets to be driven, it is necessary to determine, from a survey of the plans, the size and length of the welds required.

Table 100, compiled from information courteously supplied by Westinghouse Electric and Manufacturing Co., may be used in estimating field costs of rivetting. Due allowance has been made in the table for the lost time incidental to all construction operations, but it is to be remembered that the amount of information available as to welding costs is as yet very small and that more information will constantly become available, as the experience in this branch of the work

becomes more extensive, and the estimator should therefore constantly seek to increase his fund of knowledge on the subject.

Overhead expenses, supervision, insurance and the usual incidentals should be added to these costs as explained for other branches of work in this book.

TABLE 100.—ARC WELDING OF STRUCTURAL STEEL

Size of fillet	Units required per 100 linear feet of weld			
	Pounds electrode	KWH power	Hours welder	Hours helper
3/16 inch	24	45	9	3
1/4 inch	44	70	14.5	4.9
5/16 inch	68	100	20	6.7
3/8 inch	96	140	26.5	8.9

NOTE.—Electric motor driven welder weighs about 1,600 pounds crated. Gas engine driven welder weighs about 1,800 pounds crated.

The annual charge for depreciation, interest and maintenance is estimated at 45 per cent for the electric driven machine and 60 per cent for the gas engine driven machine, both based upon original purchase price.

SECTION II. STEEL JOISTS

A comparatively recent development in fire resistant floor construction is the use of light weight steel beams or joists, either of the solid rolled type or the trussed open web type. Over these joists, which may be spaced from 12 to 30 inches on centers, is placed a covering of metal lath, which acts both as centering or forms and reinforcement of the 2- or 2½-inch concrete floor slab.

The under side of the floor construction is generally protected by metal lathing and plastering in the ordinary manner.

TABLE 101.—WEIGHTS OF STEEL JOISTS PER SQUARE FEET (Including accessories) in Fire Resistive Floor Construction
(Courtesy Kalman Steel Company)

Joist depth, inches	Clear span		Weight of joists per square foot of floor for live loads shown				
	Feet	Inches	40 pounds	50 pounds	60 pounds	75 pounds	100 pounds
8	12	0	2.1	2.1	2.2	2.4	2.8
8	14	0	2.5	2.7	3.0	3.4	3.9
8	16	0	3.2	3.6	3.9	4.2	5.1
10	14	0	2.2	2.3	2.5	2.8	3.4
10	16	0	2.7	2.9	3.2	3.5	4.2
10	18	0	3.1	3.5	3.7	4.3	5.0
10	20	0	3.9	4.2	4.6	5.2	6.1
12	16	0	2.6	2.6	2.7	3.0	3.5
12	18	0	2.8	3.1	3.5	3.9	4.4
12	20	0	3.3	3.6	3.9	4.4	5.2
12	22	0	3.8	4.2	4.5	5.0	6.1
12	24	0	4.6	5.0	5.4	6.0	7.0
14	22	0	3.6	3.9	4.2	4.7	5.6
14	24	0	4.2	4.7	5.2	5.7	6.8
14	26	0	4.7	5.2	5.6	6.2	7.3
14	28	0	5.2	5.8	6.1	6.9	8.3
16	26	0	4.7	4.7	5.2	5.6	6.7
16	28	0	4.9	5.4	5.9	6.6	8.0
16	30	0	5.7	6.4	7.0	7.6	9.2
16	32	0	6.5	6.9	7.6	8.6	10.0

NOTE.—Floor construction consists of 2-inch concrete slab on metal lath over steel joists and metal lath and plaster ceiling. The dead load is assumed at 40 pounds per square foot plus 25 pounds for partitions and floor finish making a total of 65 pounds per square foot.

Designed in accordance with the Specifications of the Steel Joist Institute.

The common practice is for the manufacturer of or dealer in the joists to give a lump-sum figure for all of the joists and top-lath required for a given job, and also to state the weight of the materials which the contractor will have to handle.

For convenience in estimating, Table 101 is included. It enables one to compute the approximate tonnage of steel joists for any ordinary job. The weight of the lath can, of course, be readily determined from the specifications, since it is customary to specify it by the weight per square yard.

Cartage costs can be figured as for any other material.

Erection costs can be figured on the following basis:

Joists, 15 hours per ton.
Top lath, 30 hours per 100 square yards.

Where it is required that joists must be spot-welded to the supporting girders, figures should be obtained from someone having the necessary equipment for such work or an allowance of 4 hours per 100 welds included.

SECTION III. STEEL SASH

While there are several makes of steel sash on the market, all ordinary factory type side-wall sash are made to the same dimensions, the glass sizes being

10 by 16,
12 by 18,
14 by 20,

for the full lights, the dimensions of lights in ventilators being 1 inch less on the outer edge, or frame, of the ventilator.

Thus, a six-light ventilator, consisting of two rows of three lights each, would be arranged thus:

13 by 19	14 by 19	13 by 19
13 by 19	14 by 19	13 by 19

NOTE.—Standard size of glass 14 by 20. (See page 185.)

This variation of size need not be considered when taking off quantities for estimating or securing prices, but should

be kept in mind when listing glass for purchase or shipment, unless it is planned to do the trimming at the building.

Different manufacturers used to have their own systems of denominating the various sizes of sash made by them but that used by the Detroit Steel Products Co. is the simplest and a list made on that basis will be perfectly clear to other manufacturers when embodied in a request for prices or an order for shipment.

In that system,

10 by 16 sized lights are listed as X
12 by 18 sized lights are listed as Y
14 by 20 sized lights are listed as Z
16 by 22 sized lights are listed as P.

The first figure written down is the number of lights in the width of the sash, the second figure is the number of lights high, the third figure is the number of ventilators, the fourth figure is the number of lights in each ventilator, and the fifth figure is the number of rows under the ventilator. Thus, a list reading

3 sash—Z47–1–4–1
5 sash—Z47–1–4–4
2 sash—X55–1–6–1
2 sash—Y55

would mean

3 sash for 14 by 20 glass, 4 lights wide, 7 lights high, 1–4-light ventilator, 1 row up from bottom.
5 sash, same size, 1–4-light ventilator, 4 rows of lights below ventilator.
2 sash, for 10 by 16 glass, 5 lights wide, 5 lights high, 6-light ventilator, 1 row up from bottom.
2 sash for 12 by 18 glass, 5 lights wide, 5 lights high, no ventilators.

When vertical or horizontal mullions are required, a proper notation should be made of them as, for instance, 3 windows, each consisting of 3 units 55-1-6-1 and 2 vertical mullions.

Catalogues of the sash manufacturers give full particulars as to over-all dimensions of all units.

Because sash prices vary constantly with the steel market and with other causes, it is not wise to use published price lists as a basis for estimating but a list should always be made and sent out for prices or else the plans should be sent and a lump-sum quotation received.

Where the work consists entirely of single units of steel sash, particularly in brick or cement-block walls, it is generally more economical for the builder to do his own erection, but where large openings are filled with "multiple-unit" sash, the trained organizations employed by the sash companies can show greater efficiency and it is always wise to get the sash companies' erection figures when possible.

In brick walls, it is practicable to set small sash in place (as is done with wood window frames) and to build the brick work up to the sash, but in concrete walls it is always necessary to leave rebates in the jambs and to set the sash later.

After the sash are set it is necessary to point or caulk around them, which is rather an expensive job, so now a patented metal rebate strip is being introduced which obviates this pointing.

Costs of erecting steel sash can be determined from the following tables:

TABLE 102.—ERECTING STEEL SASH

(Hours per 100 square feet)

	Personal observation	As reported by manufacturers
Single unit side wall sash........	8.0	3.5
Multiple unit side wall sash.....	10.0	4.4
Monitor sash..................	11.0	4.4
Casements....................	15.0	
Double hung windows..........	30.0	

TABLE 103.—POINTING STEEL SASH
(Hours per 100 linear feet)

Brick jambs	2.5
Concrete jambs	4.0

The erection of single-unit sash can be handled by any men who are competent to determine when they are plumb and straight but multiple unit and monitor sash are best handled by iron-workers who are experienced in setting sash.

Pointing of jambs is claimed by masons as their work but can readily be done by handy laborers.

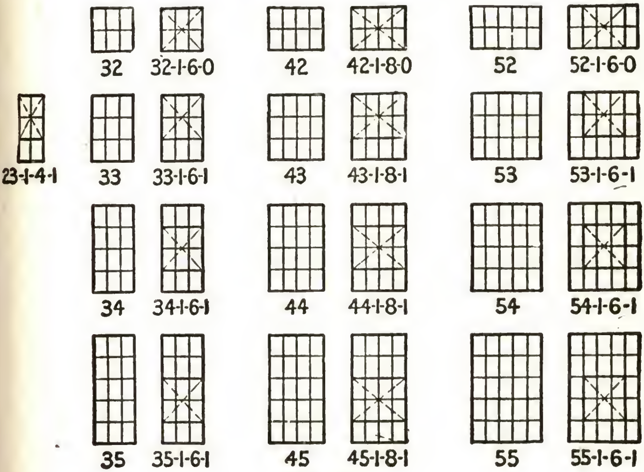

FIG. 20.

STANDARD WINDOW OPENINGS

No. of lights	Wide	High
2 lights	2′ 5⅝″	3′ 5⅝″
3 lights	3′ 8″	5′ 2″
4 lights	4′ 10⅜″	6′ 10⅜″
5 lights	6′ 0¾″	8′ 6¾″

GLASS SIZES

The 14″ × 20″ glass size occurs only in stationary portion of windows. All lights at top and bottom of ventilators must be 1 inch shorter and all lights at sides of ventilators must be 1 inch narrower than in stationary portion of window.

FIG. 21.—(*Courtesy General Fireproofing Company.*)

SECTION IV. GLASS AND GLAZING

Estimating quantities of glass for steel sash work is a very simple operation, since there is such a limited range of glass sizes likely to be used and since the operation of listing the sash gives us a check on the total number of lights required.

Thus, the simple multiplication of the number of units of each denomination by the first two figures of the denomination gives the number of lights.

For instance, the item reading

3 sash—Z47–1–4–1
5 sash—Z47–1–4–4
2 sash—X55–1–6–1
2 sash—Y55

would be extended thus:

	Lights
14 by 20 glass (3) by 4 by 7	84
(5) by 4 by 7	140
	224
10 by 16 glass (2) by 5 by 5	50
12 by 18 glass (2) by 5 by 5	50
Total	324

If the glass is all of one kind, and if no distinction need be made of the sizes for ventilators, the quantities thus taken will be all that are required.

If, however, as is usual, the first two rows of glass are some grade of clear glass and the other rows are some grade of obscure glass, the necessary distinctions will have to be made in the list.

Care should be taken to specify exactly the same grades of glass in the list as are called for in the specifications as the substitution of glass only one grade poorer might create considerable trouble.

Glass manufacturers publish a list giving the stock sizes of all kinds of window glass, the number of lights packed in a box and the price per light or per box. These prices are

subject to large discounts which vary considerably and it is essential either to get a price on your own glazing list or the latest discounts from the standard list.

A similar list is published for plate glass and it gives the details as to cost of bevelling, etc.

I have been told that the Union rules in some districts limit the number of lights that may be glazed in steel sash work to 100 per working day but I have seen expert men put in 200 or more lights day after day. Table 104 which follows is a safe one to follow since the error, if any, is on the side of safety.

TABLE 104.—GLAZING STEEL SASH

(Hours glaziers' time per 100 lights)

Glass size	Side walls		Monitors	
	Summer	Winter	Summer	Winter
10 by 16	7	8	8	9
12 by 18	7	8	8	9
14 by 20	8	9	9	10
16 by 22	8	9	9	10
24 by 32	.	.	24	27
24 by 46	.	.	26	29
24 by 58	.	.	28	32
24 by 70	.	.	30	36

TABLE 105.—PUTTY

(Pounds putty per 100 lights glass)

8½ by 11	60	16 by 22	112
9 by 13	68	24 by 32	170
10 by 16	80	24 by 46	210
12 by 18	88	24 by 58	256
14 by 20	100	24 by 70	280

NOTE.—For glazing in steel sash, "steel-sash putty" should be used. It is furnished by the manufacturer of the sash at a price usually less than the cost of preparing it locally.

GLASS SIZES

NOTE: LIGHTS IN VENTILATORS (NOT LETTERED) ARE "A" SIZE · 8"x12" GLASS

	GLASS SIZE	CUT FROM
A	8"x12"	STOCKED
B	8 11/16"x12 5/8	STOCKED
C	8 11/16"x12"	STOCKED
D	8 11/16"x11 3/4"	STOCKED
E	10"x12"	R
F	11 3/16"x11 3/4"	R
G	TEMPLATE	C
H	TEMPLATE	M
J	TEMPLATE	M
K	TEMPLATE	R
L	TEMPLATE	D
M	11 1/4"x16 1/2"	STOCKED
N	TEMPLATE	M
O	8 11/16"x10 1/2"	D
P	8 11/16"x11 3/16"	D
R	11 3/16x12 5/8"	STOCKED
S	11 3/16"x12"	R
T	11 3/16"x10 1/2"	R
U	11 3/16x11 3/16	R
V	8"x10"	A
BB	8 3/8"x12 5/8"	STOCKED
CC	8 3/8"x12"	STOCKED
LL	8"x9 7/8"	A
MM	TEMPLATE	D

LIGHTS NOT STOCKED ARE CUT IN FIELD FROM STOCK SIZE GLASS INDICATED

NOTES

VC = VENTILATOR IN CENTER

TYPES MARKED R-L CAN BE FURNISHED EITHER RIGHT HAND AS SHOWN OR LEFT HAND

THE HANDING OF A CASEMENT IS DETERMINED BY THE LOCATION OF HINGES ON THE VENTILATOR WHEN VIEWED FROM THE OUTSIDE. A CASEMENT WITH VENTILATOR HINGED AT THE RIGHT IS RIGHT HAND. ONE WITH THE VENTILATOR HINGED AT THE LEFT IS LEFT HAND.

NOTE: TYPES SHOWN SHADED ARE CARRIED IN STOCK. OTHER TYPES ARE STANDARD.

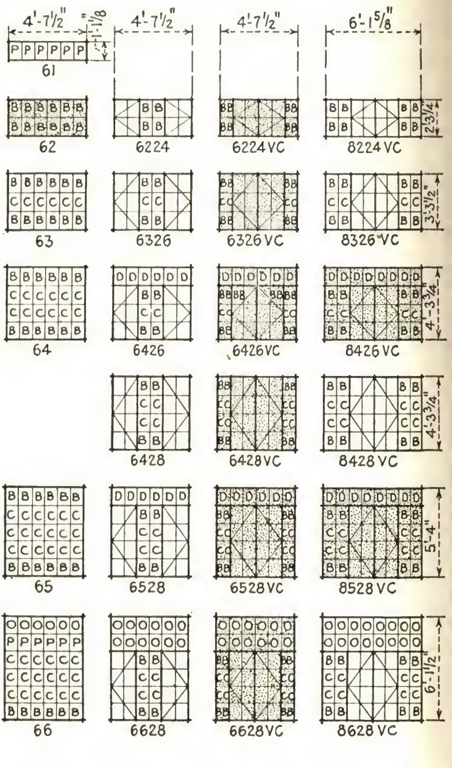

FIG. 22.—Standard Steel Casements. (*Courtesy Detroit Steel Products Co.*)

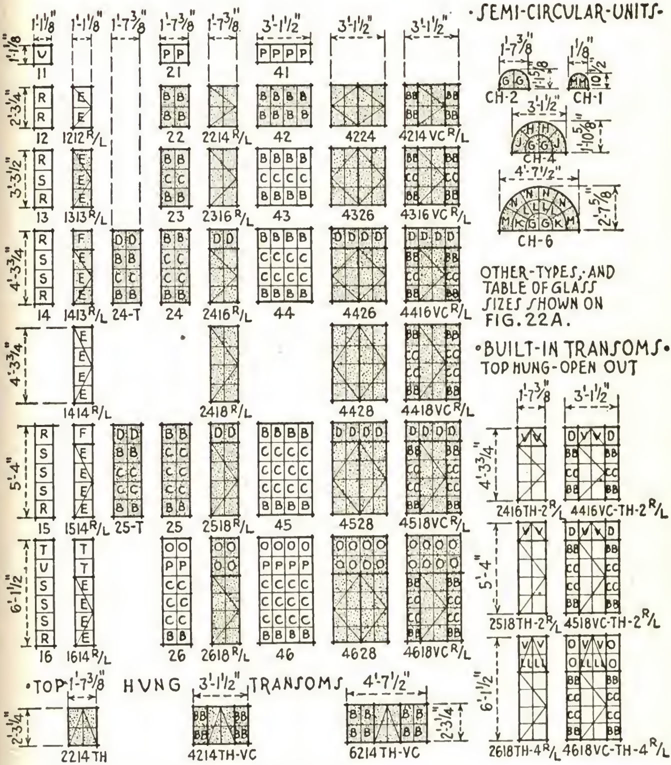

FIG. 22A.—Standard Steel Casements. (*Courtesy Detroit Steel Products Co.*)

CHAPTER XI

LATHING, PLASTERING AND STUCCO WORK

SECTION I. WOOD LATHING

Until we get a great many more people to learn the plasterer's trade, plasterers will continue in much greater demand than the available supply and every building boom, or near boom, is going to see competition among builders for the plasterers that can be had. This always results in sending wages up and daily production down.

As long as such conditions last, any data submitted for the purpose of estimating plastering costs must be used with a great deal of judgment and due consideration of all existing local conditions.

The same remarks apply, though probably not with equal force to metal lathing and furring.

Wood lathing, on the other hand, is usually paid for at an agreed price per 100 or 1,000 laths, so the lather has a definite incentive to do a good day's work. And, if the price be known in advance, the estimator need only determine the number of laths needed and multiply it by the price to determine the labor cost of the work.

Since the laths themselves are purchased by the thousand, the following table will give all the information needed, after the area to be covered has been determined.

The time given is for skilled lathers. When lathers are not available and the lathing is done by carpenters, the time must be increased from 25 to 33⅓ per cent depending upon the skill of the men employed.

Right here it is well to mention that trade practises in many communities affect the methods to be used in surveying quantities of lathing and plastering. For instance,

TABLE 106.—WEIGHTS OF WOOD LATHS
(Per bundle of 100 laths)

	Spruce		Hard pine	
	Green, pounds	Dry, pounds	Green, pounds	Dry, pounds
1 × 32	17.9	12.8	29.2	20.8
1 × 48	27.5	19.5	45.0	31.8
1⅛ × 48	40.5	29	66.0	47.5
1½ × 48	45.5	32.5	74.0	53.0
1⅝ × 48	52.5	35	85.5	57.0

TABLE 107.—WOOD LATHING

Kind of lath	Nailing centers, inches	Lath per square yard	Pounds nails per 1,000 lath	Hours time per 1,000 lath
1 inch wide, 32 inches long.....	12	26.0	9	4.75
1 inch wide, 32 inches long.....	16	26.0	7	4.50
1 inch wide, 48 inches long.....	12	19.5	14	5.25
1 inch wide, 48 inches long.....	16	19.5	10	5.0
1⅛ inches wide, 48 inches long	12	19.0	14	5.25
1⅛ inches wide, 48 inches long	16	19.0	10	5.0
1½ inches wide, 48 inches long	12	14.5	14	5.25
1½ inches wide, 48 inches long	16	14.5	10	5.0

in certain sections no opening less than 21 square feet is deducted; in others, openings under 2 feet in width are not deducted and one-half of all wider openings is deducted. Sometimes curved work is charged at double the price of flat work. Every estimator should familiarize himself with the practises in the sections in which he works and govern

himself accordingly when considering work to be sub-let or when undertaking work on a unit-price basis.

The data included in this discussion are, however, intended for the man who intends to employ the plasterers, lathers and laborers himself and wishes to estimate accordingly. He should take off actual net areas, and make the necessary additions for corners and other items, as will be explained later.

Sometimes, plaster-boards are used as an effective substitute for the lath and for the first coat of plaster. In figuring it should be remembered that the boards are made 32 inches by 36 inches, so as to be suited for 12-, 16-, or 18-inch nailings, and, therefore, each sheet contains only 8 square feet instead of a full square yard. Thus, if the boards are bought at 24 cents each, a yard costs 9/8 of 24 cents or 27 cents.

TABLE 108.—APPLYING PLASTER BOARD

Thickness, inches	Pounds per square yard[1]	Pounds nails per square yard		Hours[2] per square yard	
		12-inch nailing	16-inch nailing	12-inch nailing	16-inch nailing
1/4	13.5	0.19	0.15	0.09	0.08
3/8	18.0	0.20	0.16	0.11	0.10
1/2	22.5	0.21	0.17	0.14	0.13

[1] Prices for plaster board are frequently quoted on the basis of 1,000 square feet.

[2] In many places, plaster board is applied by carpenters, regardless of whether it is finished by plastering or painting.

Recently, several manufacturers of plaster board, or gypsum lath as it is sometimes called, have produced sizes of boards which are more conveniently handled than the older sizes. These new sizes are:

16 × 32 inches, weight 6½ pounds per sheet, packed 9 sheets per bundle
16 × 48 inches, weight 10 pounds per sheet, packed 6 sheets per bundle.

The same quantities as given in the table should be used in figuring costs, noting, however, that the prices quoted by the dealers are generally on the basis of a thousand square feet and not on the yard basis.

SECTION II. METAL FURRING AND LATHING

There is such a wide variety of kinds of metal lath that it is hardly practicable to tabulate accurately the unit-time-costs of installing every kind of lath under all different conditions.

Figuring the cost of the lath itself is a simple matter, since it is only necessary to take off actual quantities of surfaces to cover and add the following allowances for waste:

Plain surfaces, add 5 per cent
Beams, pilasters, etc., add 10 per cent
Cornices, add 20 per cent
Domed and groined work, add 25 per cent

Since quotations can be readily obtained on the kinds of laths required, it is only necessary to multiply the quantity by the price.

The labor, however, will vary with the difficulty of handling the materials. Naturally, a heavier gauge cannot be manipulated as handily as a light gauge lath, and various types of expanded lath, even of the same gauge, will vary materially in their ease of manipulation.

For all ordinary work on wood furring, the following figures may be used, and 1 pound of staples should be included for each 20 square yards of lath.

TABLE 109.—METAL LATH ON WOOD FURRING
(Hours per 100 square yards)

	Spacing of studs or furring		Percentage of lath to be added for waste
	12 inches	16 inches	
Flat ceilings	14	10	5
Walls and partitions	12	9	5
Simple coves	24	18	10
Simple cornices	26	20	20
Elaborate cornices	30	..	25
Beams and girders	28	22	10
Panel or arch ceilings	16	..	10
Domed or groined ceilings	18	..	25

NOTE.—The time here will allow for the ordinary plank scaffolds needed for rooms not more than 9 feet high. For high ceilings, the cost should be figured as indicated on page 150.

Where metal furring is required, except in the case of "self-furring" lath, it is necessary to calculate the amount of furring material separately as it may vary from 5 pounds to the square yard in the case of comparatively simple cornice work, up to 15 pounds to the square yard in the case of heavy hung ceilings.

In doing this, it is necessary to take off all hangers, cross-bars and longitudinal bars and to figure their total weight by the method explained for builders' wrought-iron work being sure to add 15 per cent for waste in cutting, bending etc., and extend it at the current price per pound.

The labor cost of placing the material may be calculated from Table 110.

TABLE 110.—METAL LATH ON METAL FURRING

	Placing furring, hours per 100 pounds	Pounds[2] steel furring per yard	Placing lath,[1] hours per 100 square yards	
			16 inch spacing	12 inch spacing
Simple beams	8	7.5	20	26
Heavy beams	9	7.5	24	30
Heavy cornices	9	7.5	26	32
Panelled ceilings	8	9	14	18
Groined ceilings	12	12	16	20
Domed ceilings	12	11	16	20
Flat ceilings (clipped)	8	7	14	18
Flat ceilings (hung)	9	9	14	18
Partitions	3	8	11	14
Partitions (wood studs)	....	....	10	13
Walls	5	3.0	11	14
Coves	8	7.5	20	26

[1] Allow same percentages for waste as in previous table. Scaffolding same as for wood furring.

[2] This figure should be used only for approximate estimating. Accurate figures can be made after examining specifications in each instance. In some cities, weight and spacing of hangers and furring are governed by building code.

SECTION III. PLASTERING

There is practically no limit to the number of different kinds and qualities of plaster finishes that may be obtained, each with a varying labor and material cost, and there is also a wide range of manufactured products available, each of different covering capacity and varying cost of application.

Manifestly, it will be impossible to discuss thoroughly all of these finishes in this text, so we shall endeavor to treat only those which are in most general use.

Right here it may be well to add a word of caution to the estimator. It is not at all unusual to find a clause in

specifications stating that the work must be done in strict accordance with all state and local regulations.

In certain places, local custom provides that not less than two coats of plaster must be applied, while in one State there is a law requiring that all plastering must consist of "scratch, brown and finish coats."

So, even though good mechanics can do a good job with only one coat on "Sackett" or similar board, or even though the specifications require only one or two coats, it is necessary to figure upon putting on the number required by the regulations.

The man who has to estimate the cost of plastering should familiarize himself with all of the various kinds of plaster available in his market, their cost, covering capacity, workability, etc., so that he may make the most intelligent use of the information contained in this section.

In using the tables which follow, keep in mind that they include the cost of all ordinary scaffolding but when the walls are over 12 feet high, it is usual to have the carpenters build a staging, which is often left in place for the use of the painters, or decorators, later.

Be sure that the estimate includes such staging under the proper heading.

If the patent plaster is bought in the prepared form, requiring no further addition of sand, simply mixing it with water, a reduction of 1 hour of laborers' time may be made in any of the above figures for scratch and browning coats.

When using the table to prepare an estimate on a piece of plastering, be sure to take the proper figures for each of the coats required and add them together to get the total labor cost.

All of the figures in the table are for an ordinary "good" job of plastering. It is possible to reduce the time required, except for scratch coats, very appreciably if a good job is not wanted but it is well to ascertain definitely what will be expected before cutting prices.

Do not forget to figure the cost of elevator or hoist when estimating for a multi-story building.

TABLE 111.—LABOR COSTS ON PLAIN PLASTERING
(Hours of masons' time per 100 square yards)[1]

Base	Scratch Coats		
	Patent plaster	Lime plaster	Portland cement[2]
Brick or hollow tile	4.5	4.5	5.0
Concrete	5.5	5.5	...
Wood lath	4.75	5.0	5.5
Metal lath	5.25	5.5	6.0
Ribbed metal lath	6.5	7.0	7.5
	Browning coats		
Scratch coat	7.0	7.5	9.0
Brick or hollow tile	7.5	8.0	9.5
Plaster board	7.0	7.5	9.0
	Finishing coats		
	On browning coat	On plaster board[3]	
White skim	8.5	9.0	
Hard finish	9.5	10.0	
Sanded white	10.0	10.5	
Floated sand	11.0	11.5	
Keenes cement	12.5	13.0	
Caen stone	40.0		

NOTE.—Allow 0.15 hour elevator time per 100 yards of plaster per story for all above first story.

[1] To find the cost per square yard for any job, add together the cost of each of the coats specified. Allow the same number of hours of laborers' time as indicated for masons. This will cover mixing and serving mortar and building of scaffolds where room is not over 9 feet high. For high ceilinged rooms, see cost of scaffolds on page 150.

[2] Finishing coats of Portland cement plaster cannot be applied practicably to base coats of gypsum plasters.

[3] Finishing coats directly on plaster board are not recommended, but are sometimes used in cheaper construction.

SECTION IV. ORNAMENTAL WORK

If any of the ornament required is such that it cannot be "run" in the ordinary manner, it is necessary to secure

a price from a shop having facilities for making plaster casts. These include dentils, egg-and-dart ornament, wreaths, etc., etc., and must be planted onto the cornices or other members which they ornament.

An allowance of 1 hour of plasterers' time should be included for each 3 linear feet of "planted-on" ornaments and each 2 square feet of panels, bas-reliefs or similar ornaments. This covers the setting only and does not include any part of the cost of modelling or casting.

In figuring the labor cost of all ordinary "run" work, such as coves, mouldings and rails, the simplest method that is at all accurate is to measure the girth of the member, including all the mouldings and figure it on the basis of the "developed" area. It should be remembered, however, that it takes as much time to run a moulding of 8 inches girth as it does one of 12 inches girth, so the girth should always be figured in full feet, when fractional dimensions occur. The full length should be taken, doubling for all corners and miters and the resultant area forms the estimating quantity.

TABLE 112.—RUNNING ORNAMENTAL PLASTER
(Time per 100 square feet measured full girth of members)

	Plaster	Keenes cement	Portland cement
Masons....................	20	24	48
Laborers....................	8	8	8

TABLE 113*A*.—RULING TO IMITATE TILING
(Time per 100 square feet)

	Plaster	Keenes cement	Portland cement	Caen stone
Masons..............	3	4	3	10
Laborers..............	¼	¼	¼	2

TABLE 113B.—MISCELLANEOUS ORNAMENTAL WORK

(Hours of masons' time to be added)

	Hours per 100 Linear Feet
Planting on panel strips and moldings	34
Planting on bas-reliefs, etc.	50
Running corners and arrises	8

NOTE.—Portland cement finishes, whether of white or gray cement, cannot be applied over any sort of gypsum undercoats. This is sometimes overlooked by specification writers and has often cost contractors appreciable sums of money because, while the finish will appear at first to be holding firmly, in a short time it will entirely separate itself from the backing.

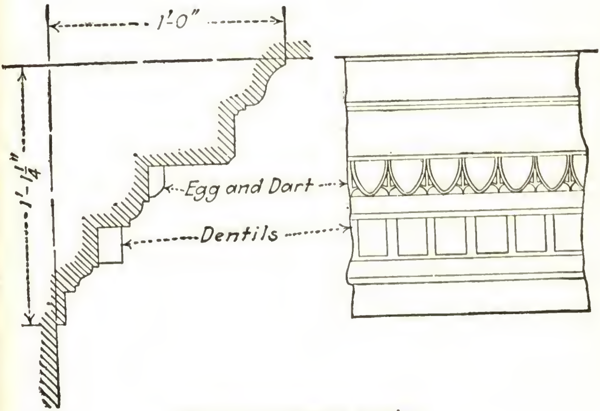

FIG. 23.—Plaster cornice.

TABLE 114.—PLASTERING MATERIALS

(Quantities per 100 square yards)

	Cubic yard, sand	Barrel, lime	Bushel, hair	Ton, patent plaster	Ton, plaster of Paris	Barrel, Portland cement
Lime scratch:						
On wood	0.63	1.5	1.5			
On metal	0.80	1.9	1.9			
On brick	0.46	1.0	1.0			
On board	0.46	1.0	1.0			
On tile	0.46	1.0	1.0			
Patent scratch:						
On wood	0.50	...	...	0.25		
On metal	0.65	...	...	0.32		
On brick, etc	0.38	...	...	0.20		
On gypsum lath	0.50	...	...	0.12		
Wood pulp scratch	.....	...	...	0.35		
Portland scratch	1.20	0.7	1.5	....	.....	4.6
Lime mortar brown	0.875	1.5	1.0	....		
Patent brown	0.70	...	...	0.35		
Woold pulp brown	.....	...	...	0.50		
Portland brown	1.20	0.7	1.0	....	.....	4.6
Finish coats:						
Skim	.....	1.5	...	....	0.015	
Hard	.....	1.5	...	....	0.04	
Sanded white	0.25	0.5	...	....	0.10	
Sand floated	0.25	0.5	...	....	0.10	
Keenes	.....	0.5	...	....	0.25[1]	
Caen stone	.....	...	...	....	1.25[1]	
Portland cement	0.62	0.5	...	....	.....	1.6

NOTE.—To get the cost per square yard of plaster, figure the total of the materials needed for each coat and add together.

[1] Figure at the special higher price for these materials instead of plaster of Paris.

SECTION V. STUCCO

The operations involved in stucco-work are essentially the same as those involved in interior plastering and, like plastering, it is impracticable to give complete cost data for all kinds within the limits of such a book as this.

The best results in stucco work are, however, usually obtained by workmen who specialize largely in that branch of the work and who have developed a technique that

enables them to produce a quality of work far beyond that of the all-round plasterer.

Beside the ordinary kinds of cement-stucco, there are numerous patent or proprietary preparations on the market and, as with plasters, the estimator should obtain all possible data upon their use, covering capacity and workability from the manufacturers, as well as from persons who have used the preparations.

It is well to remember that, while they are undoubtedly actuated by motives of the purest intent, manufacturers are likely to be very optimistic about the cost of using their products, and sometimes results in actual practise are disappointing.

When getting information as to costs of applying different proprietary preparations, it is well to ask for details as to the quantity applied in a given time-period per man, the number of coats required and it should also be noted that some of these preparations require an especially prepared base for their successful use. Costs in dollars or cents per square yard are not very helpful unless all surrounding conditions are known.

Portland cement stucco is the most common stucco in general use (though magnesite stuccos are rapidly increasing in popularity) and it is probably also the most adaptable, since it can be applied to almost any lath or masonry base, except that it can seldom be applied successfully to a concrete surface that has not been thoroughly roughened and washed.

Knowing the base to which the stucco is to be applied and the number of coats required by the specifications, you can readily calculate the quantities of materials needed for any ordinary stucco job from Table 114.

Where the surface is to be enriched or "enlivened" by the use of pebbles or crystals, it is necessary to add the cost of those materials, which are usually sold by the 100 pounds or by the ton by people specializing in that line.

Fine grit or crystals, allow 5 pounds per square yard.

One-fourth-inch pebbles, allow 20 pounds per square yard.

Intermediate sizes require proportionate amounts.

NOTE.—White Portland cement is much more expensive than ordinary grey cement and white sand sometimes costs as much per bushel as ordinary sand does per yard.

The labor costs of the scratch and brown coats, as may be required, can readily be calculated from the column in Table 112 headed "Portland cement."

Table 115 gives the data for figuring the cost of a variety of finish coats, which are to be added to the cost of the rough coats.

TABLE 115.—LABOR COSTS ON STUCCO FINISH COATS
(Hours per 100 square yards)

	Masons	Laborers	Tons grit or crystals for dash
Plain finish	12	9	
Sand float	15	11	
Coarse pebble dash	16	12	1.0
Fine pebble dash	16	12	0.25
Slap dash	15	11	
Broomed	15	11	

NOTE.—For Portland cement stucco, figure materials as for cement plaster. See Table 114. For patent stuccos, get covering capacities from manufacturers. Figure scratch and browning coats, when required, as in Table 111. Figure scaffolding as for brickwork.

CHAPTER XII

PAINTING AND PAPER-HANGING

SECTION I. GENERAL

As a general rule, because of the fact that the labor items in a painting estimate will amount to a great deal more in money than the material items will, and because the labor required to work around an opening is at least as much as that which would be required if there were no opening, painters do not deduct openings when making estimates.

It is also quite customary to consider each linear foot of wood trim, when the actual width is a foot or less, as a square foot, because there is very little difference in the time required to cover a member a foot wide and a narrower one.

On the other hand, there is a great difference in the amount of paint that will be used by different workmen, depending upon how thoroughly they will brush out the paint and a day's work will also vary greatly with different men.

SECTION II. MATERIALS

Of late, it has become more and more customary for architects to specify well-known brands of ready-prepared paints because they feel more certain of the results they will obtain than if they depend upon the painter's own judgment in mixing and preparing the paint.

However, a great deal of paint is still mixed on the job or in the painter's shop, and the estimator should have a clear idea of the amounts of the ingredients needed to prepare a given quantity of paint.

Table 117 has been prepared for that purpose.

TABLE 116.—COVERING CAPACITY OF PAINTS

Nature of surface	Priming coat		Other coats	
	Gallons per 100 square feet	Square feet per gallon	Gallons per 100 square feet	Square feet per gallon
Smooth boards	0.2	500	0.143	700
Clapboards	0.222	450	0.159	630
Plaster	0.2	500	0.143	700
Brick	0.25	400	0.222	450
Stucco	0.235	425	0.2	500
Concrete	0.235	425	0.2	500

NOTES.—New stucco or concrete surfaces must have their causticity neutralized. This can be done by the application of one coat of 1 to 9 soution of zinc sulphate in water.

TABLE 117.—PAINT INGREDIENTS
(To make 10 gallons)

Paint	Linseed oil, gallons	Turpentine, gallons	Drier, pints	White lead, pounds	Enamel varnish, gallons
White primer	5.25	2.0	1.5	100	
Second coat	5.0	1.3	1.3	129	
Finish coat	5.75	0.2	1.5	143	
Inside finish:					
Primer	4.5	2.3	1.7	114	
Second coat	4.3	1.4	2.1	143	
Full gloss finish	...	...	...	30	9
Egg-shell	0.4	5.0	...	167	
Dead-flat finish	...	5.2	...	173	

NOTE.—To produce shades or colors add 3 to 15 pounds pigment to those quantities.

The area of surface that can be covered by a given quantity of paint depends, assuming that the same care is given in brushing out, upon the porosity of the surface, and also upon the temperature.

Of course, the first coat applied to any surface will be absorbed (except in the cases of metal surfaces) much more rapidly than the succeeding coats and thus a greater amount of paint is required for the first coat than for the succeeding coats.

Mixed paint weighs approximately 15 pounds per gallon.

White lead weighs approximately 36 pounds per gallon.

In addition to the quantities of paints and varnish required, approximately a pound of putty must be used to each 1,000 square feet of surface.

TABLE 118.—COVERING CAPACITY OF VARNISHES, STAINS, ETC.

	Hardwood		Softwood	
	Gallons per 100 square feet	Square feet per gallon	Gallons per 100 square feet	Square feet per gallon
Water-stain	0.143	700	0.167	600
Alcohol stain	0.25	400	0.286	350
Oil stain	0.182	550	0.182	550
Paste filler	0.333	300	0.333	300
Varnish	0.167	600	0.167	600
Shellac	0.143	700	0.143	700
Aniline stain	0.154	650	0.222	450
Floor varnish	0.2	500	0.2	500
Liquid filler	0.222	450	0.222	450
Kalsomine (on plaster)	....	...	0.67	150

Where rubbing down is specified, the following materials are necessary, for each 1,000 square feet of surface.

5.6 pounds petroleum
1.2 gallons kerosene
3.5 pounds powdered pumice
10 pounds waste

SECTION III. LABOR

There is very little agreement in published data as to the amount of surface that a painter should cover in a day's work. Some books give as wide a variation as from 20 to 180 square feet per hour.

Of course, such data are obtained by taking the average of entire jobs, rather than by recording the performance on each different kind of work. Obviously, some kinds of work require a great deal more time than others, and the proper procedure is to determine the production that may fairly be expected.

In Table 119 the quantities given are those that can reasonably be considered as a fair average production.

This may seem to be rather a brief method of treating the entire subject of estimating the cost of painting, yet there is hardly any ordinary specification, that will be encountered by a building contractor, that cannot be resolved into its component parts and estimated by means of the tables given in this chapter.

TABLE 119.—LABOR ON PAINTING
(Hours per 100 square feet per coat or operation)

	Priming coats	Finishing coats
Outside woodwork	0.5	0.45
Clapboards	0.55	0.5
Outside trim	0.6	0.48
Filling interior trim	1.3	
Staining interior trim	0.6	
Sand papering trim	1.3	
Rub down trim	1.3	
Varnish trim	....	0.67
Enamelling trim	....	0.85
Calcimining plaster	0.3	0.6
Painting brickwork	0.9	0.7
Painting plaster	0.9	0.7
Painting concrete	0.9	0.7
Oiling brickwork	0.9	0.7
Filling floors	0.7	
Waxing floors	....	0.5
Polishing floors	....	1.0
Varnishing floors	....	0.5
Staining floors	0.6	
Stencilling	....	5.0

Example.—Assume a building for which the following areas to be covered have been computed:

14,000 square feet 2 coats mill-white on ceilings.
6,500 square feet 3 coats mill-white on brick walls.
2,400 square feet 2 coats graphite paint on steel sash.
1,800 square feet 2 coats white paint on cornices.
14,000 square feet 2 coats cement coating on floors.

The cost of the materials would be as follows:

140 squares × 0.2........	28	gallons mill-white for first coat on plank
140 squares × 0.143......	20	gallons mill-white for second coat on plank
65 squares × 0.25.......	16.25	gallons mill-white for first coat on brick
65 squares × 0.222......	14.5	gallons mill-white for second coat on brick
	14.5	gallons mill-white for third coat on brick
Total.................	93.25	gallons, say 94 gallons mill-white.

24 squares steel sash × 0.2 × 2 coats, 9.6 gallons, say 10 gallons of graphite paint.

18 squares × 0.2.........	3.6	first coat
18 squares × 0.143.......	2.6	second coat
	6.2,	say 7 gallons white paint on cornice.
140 squares × 0.235......	33	first coat
140 squares × 0.2........	28	second coat
	61	gallons cement coating on floors

Labor:

	Squares		
Wood work, ceilings	140		
Cornices........	18		
	158	× 0.5.......	79 hours priming
		× 0.45......	72 hours finishing
Brick work......	65	× 0.9.......	59 hours priming
		× 0.7.......	46 hours second coat
		× 0.7.......	46 hours third coat
Steel sash (2 ×)	24	× 0.4.......	19 hours
Cement floor....	140	× 0.9.......	126 hours first coat
		× 0.7.......	98 hours second coat
Total..........................			545 hours

SUMMARY

94 gallons mill-white @ $1.75	$164.50
10 gallons graphite paint @ $2.25	22.50
7 gallons white paint @ $2.50	17.50
61 gallons cement coating @ $1.50	91.50
545 hours labor @ $0.85	463.25
Insurance	23.72
Contingencies, brushes, etc	50.00
Cost	$832.97

Under ordinary circumstances, the profit to be added by the painting contractor should bring this figure up to about one thousand dollars.

SECTION IV. PAPER-HANGING

On new work, it is necessary to prepare the plastered walls by giving them a coat of glue sizing before applying the wall paper. The amount of size required will vary with the smoothness and porosity of the wall, but average quantities are

0.10 gallons size per 100 square feet.
0.25 hours labor per 100 square feet.

The ideal method of paying for paper and paper-hanging is on the basis of the number of rolls actually required and used. It is then only necessary to calculate the number of rolls of each kind of paper required and to multiply by the proper prices per roll.

Prices of paper vary all the way from 15 cents to several dollars per roll and it is, therefore, necessary to get the correct prices for the papers specified.

A single roll is 18 inches wide by 24 feet long.
A double roll is 18 inches wide by 48 feet long.
Some high-grade papers are made 30 inches wide by 15 feet long.

For all ordinary purposes, the best method of estimating the number of rolls required is to multiply the perimeter of the room by its net height (from top of base-board to

border or ceiling) and then deduct the net size of any doors and windows.

Dividing the area thus calculated by 36 square feet, we get the net number of standard single rolls required.

If the paper has no figured pattern, 5 per cent should be added.

If the paper has a large figured pattern, 15 per cent should be added.

These additions will cover necessary waste in trimming and matching.

Ceiling areas are figured in the usual manner and the number of rolls determined by dividing as above.

The number of rolls that can be applied in a day's work depends a great deal upon the weight of the stock and somewhat upon the pattern, the figures given in Table 120 cover ordinary conditions.

TABLE 120.—PAPER-HANGING

(Hours per single roll)

	Light	Medium	Heavy
Walls	0.2	0.3	0.4
Ceilings	0.25	0.35	0.5
Gallons paste per roll	0.08	0.13	0.17

Borders are figured by the linear yard and a given length of border will require the same amount of labor as a corresponding length of wall paper.

CHAPTER XIII

ROOFING AND SHEET METAL. DAMP-PROOFING AND WATER-PROOFING

SECTION I. COMPOSITION ROOFING

There are as many different kinds of composition roofings as there are manufacturers of roofing felts and cements, and each varies slightly from the other in the amount and cost of materials, as well as the labor cost of application. It is, therefore, practically impossible to discuss each kind of roof in detail.

However, there are a few well-established types and a discussion of them will develop the method of estimating so that, by an examination of the specifications in each case, the estimator can determine the quantities of materials and labor required.

Those general types are

Tar and gravel, or tar and slag,
Asphalt,
Asbestos.

The common unit of measurement of roofs is the square of 100 square feet and all of the quantities are given here on that basis.

All of these types of roofs are usually applied by companies who specialize in roofing and who are prepared to guarantee their work water-tight for periods ranging from 5 to 20 years, depending upon the thickness of the roof applied.

Some of these roofs, such as the J.M. asbestos, are only applied by the manufacturers, while others. the Barrett for

instance, are applied by approved roofing contractors and guaranteed and bonded by the manufacturers of the materials.

The tables which follow give the quantities of materials required for 1 square of roof.

TABLE 121.—TAR AND GRAVEL ROOFS
(Labor and materials per square on wood decks)

	Pounds, rosin-sized paper	Pounds, felt	Pounds, pitch	Pounds, gravel[1]	Hours labor
3-ply..............	5	45	75	400	1.25
4-ply..............	5	60	100	400	1.50
4-ply (Barrett).....	5	60	125	400	1.75
5-ply..............	5	75	125	400	1.75
5-ply (Barrett).....	5	75	150	400	2.25

(Labor and materials per square on concrete decks)

3-ply..............	..	45	110	400	1.50
4-ply..............	..	60	135	400	1.75
4-ply (Barrett).....	..	60	175	400	2.00
5-ply..............	..	75	150	400	2.00
5-ply (Barrett).....	..	75	200	400	2.50
5-ply (Irvin).......	..	75	180	400	2.50

NOTE.—Increase the labor by 0.125 hour for each 12 feet beyond the first 25 feet which the materials must be hoisted. Winter work will increase the labor by 20 per cent of the figures in the table.

[1] If slag is used, only 300 pounds will be required.

TABLE 122.—ASPHALT ROOFS

(Labor and materials per square on wood decks)

	Pounds, rosin-sized paper	Pounds, felt	Pounds, asphalt	Hours, labor
2-ply	..	55	60	1.25
3-ply	..	70	90	1.50
4-ply	..	85	120	1.75
5-ply	5	75	120	2.00

NOTE.—For concrete decks, omit any rosin-sized paper and add 10 pounds asphalt primer. The notes under table of Tar and Gravel Roofs apply to this table as well.

TABLE 123.—ASBESTOS ROOFS

(Labor and materials per square on wood decks)

	Pounds, asbestos felt	Pounds, asphalt	Hours, labor
3-ply	60	82	1.50
4-ply	73	90	1.75

For promenade tile roofs, add to the cost of the roof membrane the cost of the tiles, hoisted onto the roof, plus the following:

TABLE 124.—PROMENADE TILE ROOFS

	For 6 × 9 tiles	For 6 × 6 tiles
Pounds, roofing composition	300	300
Hours, roofers' time	8	10
Hours, laborers' time	8	8

Prices on the pitch, felt, asphalt and asbestos will usually be quoted on the basis of a ton, while the slag or gravel will be quoted either by the ton or the cubic yard.

The cost of hauling the materials from the railroad to the site of the work can be calculated as explained for other materials in previous chapters and, besides including the insurance, an item of 5 per cent of the net cost should be included to cover miscellaneous items such as mops and small contingent expenses.

SECTION II. SLATE AND ASBESTOS SHINGLES

Roofing slates are sold by their producers at certain prices per square (sufficient slate to lay 100 square feet with standard 3-inch lap) and extra charges are made for punching and counter-sinking.

There is a wide variety of kinds, sizes and grades of slates and prices vary, according to recent lists, from \$6 to \$24 per square for slates of ordinary thickness, and up to \$70 per square for slates 1½ inches thick.

As a general rule, larger sizes of slates cost less per square than the same grade in smaller sizes and, because of the smaller number required, the labor is also less.

The estimator who has occasion to figure upon slate roofs should obtain current price lists from the producers and should also keep informed as to the differentials that are charged on less than carload orders, as well as the extras for punching and counter-sinking.

Ordinary slates will average 650 pounds per square and cartage can be figured on that basis. An average of ½ hour laborers' time will cover the cost of unloading from car to truck and ⅓ hour from truck or wagon.

The times given in the table are sufficient to include all ordinary scaffolding but an addition of ½ hour per square must be made for all curved surfaces and ⅓ hour per linear foot for all hips and valleys.

Asbestos shingles are made in a variety of sizes and colors and hip- and ridge-roll of the same material are

usually used. If the shingles are laid in "American" style, the cost of laying will be the same as for similar sizes of slate, but if they are laid in the "hexagon" or "diagonal method" the number used will be less and a saving of ½ hour slaters' time and ¼ hour helpers' time will be made.

Wood shingles and asphalt shingles are discussed in Chapter VIII.

TABLE 125.—SLATE ROOFS
(Time given includes labor for placing felt under slates)

Size, inches	Number per square	Pounds nails per square	Slater's time per square	Helper's time per square
6 × 10	695	6.25	3.3	2.0
12	534	5.30	3.1	2.0
7 × 12	457	4.70	2.7	2.0
14	374	3.75	2.6	2.0
8 × 10	514	4.00	2.7	2.0
12	400	3.80	2.6	2.0
14	328	3.25	2.6	2.0
16	277	2.75	2.6	2.0
9 × 14	295	3.00	2.6	2.0
16	247	2.50	2.5	1.8
18	214	2.10	2.5	1.8
10 × 14	262	2.60	2.9	2.0
16	222	2.25	2.7	2.0
18	192	1.90	2.5	1.8
20	170	1.75	2.5	1.8
12 × 16	185	1.80	2.6	1.8
18	160	1.60	2.5	1.8
20	142	1.50	2.5	1.8
22	127	1.25	2.4	1.5
24	115	1.20	2.4	1.5
14 × 20	121	1.25	2.4	1.5
22	105	1.10	2.1	1.5
24	98	1.00	2.0	1.5

NOTE.—Add 0.5 hour slaters' time for curved surfaces.

Add 0.34 hour slaters' time per linear foot for all hips and valleys.

SECTION III. TILE ROOFS

Cement-tile roofs of the "Federal" and "American" types are usually laid by the manufacturers under a guaranty and, since prices vary greatly with conditions, the estimator should always submit the roof plan and specifications directly to the manufacturers for their estimates.

Clay-roofing tiles may either be installed directly by the manufacturers or their representatives, or sold to the roofing contractor and installed by him. Flat, or "promenade" tile were discussed in Section I.

Clay tiles are made in "Spanish," "Mission," "Shingle" and "Imperial" types, and special ridge-rolls, hip-rolls, finials, starters, etc., are made for each type. This makes it necessary either to list the pieces carefully or to send the plans to the manufacturers and have them make a price on the entire lot.

The labor of laying and handling will be 1.5 times that of similar sizes of slates and the cartage is figured on the basis of 1,000 pounds per square for ⅜-inch shingle tile, 1,350 pounds per square for ½-inch shingle tile, 800 pounds per square for Spanish or Mission Tile.

All tile roofs (except those types which attach directly to steel purlins) must be laid over a course of 40-pound asphalt felt.

Spanish and Mission Tiles also require 90 feet of 1 by 2 furring strips and 14 laths per square.

Shingle tiles require the laths but not the furring strips.

SECTION IV. METAL ROOFS

Tin plates are furnished in a variety of grades, dependent upon whether the base stock is steel or charcoal-iron, and upon the quality and weight of the coating. Prices are quoted by the box, which contains 112 sheets of one of the following sizes:

10 by 20
14 by 20
20 by 28

the last two being the most commonly used.

The roof may be laid either with flat or standing seams. The cost of a comparatively flat tin-roof may be figured on the basis of Table 126, but no deductions should be made for small openings.

TABLE 126.—TIN ROOFS
(Materials required per square)

	14 by 20 size tin	20 by 28 size tin
Sheets tin	62	29
Pounds solder	8	5
Pounds nails	4	3
Pounds rosin	1	1
Pounds charcoal	2	2
Hours labor	7	5

Painting of the under side of the sheets, as well as cartage of materials to the work, must be estimated according to the methods previously explained and added to the estimate.

If standing-seam roofs are specified, the items of solder, rosin and charcoal are omitted from the estimate but the quantities of tin are:

	14 by 20 size	20 by 28 size
Seams on short edge	66	31
Seams on long edge	68	32

Copper roofing is always specified by the weight in ounces per square foot of the sheet copper to be used and the weight of material is thus readily figured. Five per cent will cover the waste on all ordinary copper roofing and the labor and other items will be the the same as for tin.

Stamped metal shingles, tin-plate, galvanized or copper, require the same amount of labor as for slate-shingles of corresponding sizes and, in addition, both sides of the tin-

shingles must be painted, as must also the upper-side of the galvanized shingles; though the painting of exposed surfaces may be included in the painters' specifications.

SECTION V. SHEET-METAL WORK

Ordinarily, gutters, leaders, hip-roll, ridge-roll and finials are purchased ready-made from manufacturers and it is only necessary for the builder to obtain prices on them and to calculate the cost of erection.

Gutters will be made of tin, copper, galvanized iron or zinc and will require bending to shape and installation. The specifications will determine the kind and weight of material, as well as its width, to be used. The same remarks apply to flashing.

After finding the cost of the materials, the labor cost of installation can be determined by figuring that a mechanic and helper will erect 15 linear feet an hour of hanging gutters, leaders, hip-roll, ridge-roll, base-flashing or cap-flashing.

Stepped flashing around chimneys and in similar locations can be figured on the basis of 6 linear feet per hour.

To attempt to cover the estimating of all such items of sheet-metal construction as cornices, skylights, windows, etc., would demand an entire volume in itself. Therefore, no attempt is made to discuss them here and the estimator is advised always to secure a figure from a manufacturer who is properly equipped to turn out the work.

SECTION VI. DAMP-PROOFING, CAULKING

The common methods of damp-proofing consist essentially of painting the concrete or masonry surfaces with a water-proof or water-resisting paint or compound. Damp-proofing is distinguished from water-proofing in that damp-proofing is not intended to resist water pressure.

Most damp-proofing paints have an asphaltic base and their covering capacity varies greatly with their consist-

ency (which also varies greatly with the temperature) and the roughness of the surface to which they are applied.

At temperatures of 60 degrees Fahrenheit and upward, the figures in Table 127 will apply for most of the compounds, but at lower temperatures the covering capacity will decrease rapidly and few of them can be satisfactorily applied at all when the temperature is below freezing.

TABLE 127.—DAMP-PROOFING

(Asphaltic compounds or paints)

Nature of surface	Average covering capacity		Hours required	
	Gallons per 100 square feet	Square feet per gallon	To cover 100 square feet	Apply 1 gallon
Rough concrete	1.33	75	1.33	1.0
Smooth concrete	0.80	125	0.96	1.2
Brickwork	1.33	75	1.33	1.0
Hollow-tile	1.67	60	1.67	1.0
Stone	0.80	125	1.20	1.5
Wood	0.40	250	0.56	1.4

Damp-proof paints can be applied by any laborer with sufficient intelligence to make sure that the entire surface is covered.

Example.—Required, the cost of damp-proofing 1,000 square feet of brickwork, with a compound costing $1.80 per gallon and labor at 50 cents per hour.

Compound, $1.80 × 13.3	$23.94
Labor, 0.50 × 13.3	6.65
	$30.59
Allow for brush, etc	$1.50
Insurance on pay roll	0.30
Contingencies	1.90
	$34.29

Caulking.—Ordinary caulking of door and window frames may be figured on the following basis:

Labor	4½ hours per 100 linear feet
Oakum	¼ bale per 100 linear feet
Mineral caulking compound	2 gallons per 100 linear feet

SECTION VII. WATER-PROOFING

Water-proofing methods fall into three general classes, as follows:

Membrane water-proofing, consisting of a number of plies of saturated felt or burlap, coated over and between with pitch or asphalt.

Integral water-proofing, consisting of the addition of water-proofing materials to the cement or the mixing water that is used for making concrete.

Plaster-coating, consisting of the application of a coat from ½ inch thick upward, of water-proofed cement plaster to the brick or concrete walls and floors.

Some of the water-proofings in the last two classes are applied only by the manufacturers, or their representatives, and it is always necessary to get their figures.

The other preparations are sold by the pound or gallon and the amount to be used varies with each compound, so it is necessary to obtain detailed information in each case, and estimate accordingly.

Usually the amount to be used is a certain number of pounds per bag of cement, and the procedure for estimating is the same as outlined in Chapter VI, but precaution must be taken to estimate the cost of caring for water as mentioned below.

The engineer or architect should specify the number of plies of felt or burlap to be used, when membrane water-proofing is required, also the weight per square of the felt or burlap, the kind of composition to be used for coating, and the number of pounds of coating per 100 square feet per application.

Since there will be one coating of pitch or asphalt on each side of each ply of the membrane, it is evident that

there will always be one more coating than the number of plies.

Thus, if 7-ply water-proofing is required, with 40-pound coating per application, each square would require,

320 pounds composition and
770 square feet felt or burlap.

10 per cent being allowed for lapping and waste and, if the felt weighs 26 pounds per square, its weight would be 200.2 pounds.

In computing the area to be covered, it is necessary to include all bends, angles, returns and key-ways before adding the percentage for waste.

The labor of applying the water-proofing will require an average of 0.8 hours per square for each ply of membrane and the same amount for each coating of composition.

Thus, the 7-ply water-proofing mentioned above would require:

	Hours
For placing felt, 7 plies @ 0.8............	5.6
For placing composition, 8 coatings @ 0.8	6.4
	12.0

And at 75 cents per hour this would be..	$9.00
Adding 302 pounds composition @ $35 per ton...........................	5.29
201 pounds felt @ $19 per ton..	1.91
Insurance...........................	0.45
Contingencies, including mops and fuel...	2.25
Net cost per square................	$18.90

Thus, the calculation of the cost of the actual water-proofing is a very simple matter, but the cost of caring for water during construction is often a much more serious matter than is the application of the water-proofing, and it is practically impossible to give any rules that may be followed.

For this reason, it is recommended that all water-proofing problems be referred to one of the sub-contractors specializing in that work and whose experience has taught them how to cope with almost any conditions that may be encountered.

CHAPTER XIV

INTERIOR MARBLE WORK, TILING, AND TERRAZZO

SECTION I. INTERIOR MARBLE WORK

In preparing a bill of quantities for interior marble work it is necessary to list individual pieces, so far as practicable, and otherwise to give the number of linear feet for such items as base, or square feet for such items as wainscot or flooring, and to give as complete a description as is possible. For instance,

Toilet partitions should be described by giving:

Name of kind of marble specified.
Thickness and dimensions of slabs.
Finish on sides.
Finish on edges and corners.
How slabs are supported.
Description of hardware, if to be included.

Marble base should be described by giving:

Name of kind of marble specified.
Thickness and height of base.
Length of individual pieces, when possible.
Finish.
Molding or chamfering, if any.
Method of setting.
Number of return ends required.

Each other item in the list should be described with at least as much detail, so that the manufacturer may estimate intelligently the cost of preparing the stone for the building, as it is hardly to be supposed that a builder will have facilities for taking the marble in blocks, sawing it and polishing it, even though he might be prepared to set it after delivery.

When marble is purchased from a producer, there are likely to be charges for crating and boxing, and, in less than carload shipments, trucking charges at the shipping end as well as freight charges, and the estimator must see that his estimate covers every one of these costs.

Marble averages 168 pounds per cubic foot in weight, which means an average weight of 14 pounds per square foot for each inch of thickness of slabs, and when crated for shipment it is necessary to include 2 pounds per square foot to cover the weight of the crates.

In figuring the labor costs of setting, after delivering to the site, all base and similar members should be considered at least one foot wide, and pieces wider than one foot should be counted to the next foot; fractional square feet in any slabs should be considered as a full square foot; molded members should be figured as indicated above for base, and where more than 1 inch thick, the area should be multiplied by the thickness.

Having thus determined the total area of marble to be set, this table may be used to calculate the cost.

TABLE 128.—SETTING INTERIOR MARBLE
(Hours per 100 square feet)

	Setter	Helper
Floor tiles	17	17
Stair treads	19	19
Wainscot	19	19
Base, dado cap, etc	23	23
Partitions, 1-inch thick	20	20
Partitions, 2-inches thick	23	23
Heavy rails, balusters, etc	23	23
Curved work	23	30

NOTE.—In making an estimate on setting marble work, at least 5 per cent should be allowed to cover such items as plaster of Paris, brass wire for anchors, and similar necessities which cannot readily be estimated by quantities.

SLATE WORK

It is not necessary to discuss the costs of setting slate work at any great length since the costs given in the previous section apply equally to this item.

However, practically all of the large producers of slate issue price lists and discount sheets giving the cost of practically every size of slabs used in building construction.

FLOOR TILING

Practically all kinds of floor tiling are laid upon a concrete base, 2 or more inches in thickness, and sometimes reinforced by a layer of "chicken-wire," or other form of wire fabric.

The cost of this concrete base course can be estimated from the data given in the tables on plain concrete work in Chapter VI.

The variety of kinds, sizes, and shapes of floor tiles is endless. They are made round, square, hexagonal, and have been made elliptical; they range in size from 1 inch to 1 foot or more; they are made in white, as well as almost every conceivable range of colors, and are laid in one color, or in mosaics to resemble tapestries, in geometrical designs, and in plain fields.

Naturally, it is almost impossible to give figures upon which to base estimates to cover each kind of tiling, laid in rooms of every size, with or without borders.

Small sizes of "ceramic" tiles, up to 1⅝ inches, the tiles, whether plain pattern or mosaic, are usually mounted on paper so that the actual building up of the pattern is not done at the building.

However, the tile setter must match up the several sheets of the field and the border, as well as to space them out so that the design properly covers the area.

Larger tiles are set individually and, where there is no other tile work in the building, quarry tiles are often set by bricklayers.

Beside the labor indicated in the table below, it is necessary to include the cost of a 1-inch layer of one-half cement mortar, in which the tiles are set.

On small jobs, such as single bathrooms, etc., it will be necessary to include an item to cover the time consumed in sending men to and from the work.

TABLE 129.—LAYING TILE FLOORS
(Hours per 100 square feet)

	Setter	Helper
Small ceramics: Plain field	8	8
Mosaic pattern	10	10
Border	10	10
2-inch hexagon	14	14
2- or 3-inch square	16	16
4 × 4-inch quarry or "encaustic"	14	14
6 × 6-inch quarry or "encaustic"	13	13
9 × 9-inch quarry or "encaustic"	10	10

WALL TILING

In estimating the labor cost of wall tiling it is necessary to consider each individual item, such as base, ornamental frieze, cove, or cap as though it were 1 foot wide and to figure the field of the wainscot at its actual area. Beads and exterior angle tile should be figured as 2 square feet each.

Of course, for purchasing, it will be necessary to list the exact number of each kind of pieces required.

The metal-lath and cement-plaster backing that will be required for all wall tiling can be estimated as outlined in the section on plastering, taking care to use the proper labor rate for a tile setter and remembering that you will always need a helper for every setter.

TABLE 130.—SETTING WALL TILES
(Hours per 100 square feet)

	Setter	Helper
6 × 3 tile, small rooms	17	17
large rooms	10	10
6 × 6 tile, small rooms	16	16
large rooms	9.5	9.5

TERRAZZO FLOORS

In the tables on Cement Floors in Chapter VI we gave the necessary information for figuring the cost of mixing and placing the bed of cement required for a terrazzo floor.

Having determined the cost of preparing and placing the bed to comply with specification requirements, we have but to calculate the cost of the necessary marble chips, their placing in the floor, and the final rubbing and polishing.

The chips will average 7½ pounds to the square foot and the rubbing cost will be determined by the nature of the work and whether it is done by hand. Hand rubbing will average 20 hours per 100 sq. ft.

Machine work will reduce the number of hours required on floors by one-third and on base by one-half.

CHAPTER XV

FOUNDATION WORK

WOOD PILING

The customary method of paying for wood piles is by the linear foot of pile actually driven, but sometimes a price per pile is quoted. The piling contractor may buy the piles either at a price per stick or a price per foot.

Specifications usually call for minimum diameters of butt and tip, maximum variation from straightness and the kind of wood.

It is also customary to specify that the piles shall be driven until a certain bearing value is reached.

On large operations, the probable length of piling that will be required is determined in advance by driving test piles at several different points on the lot and ordering accordingly.

To make fairly close estimate for bidding purposes, it is necessary to examine the plans and compute the time that will probably be consumed in moving the driver, as well as that actually consumed in driving, and to this must be added all of those additional costs which include:

Delivering and setting up driver.
Purchase price of piles.
Cost of delivering and unloading.
Cost of distributing them on the site.
Cutting off after driving.
Removing discarded butts.
Fixed charges on driver.
Removing driver from work.
Contingencies.
Profit.

For the purpose of the general contractor, the following information will suffice.

An ordinary "land" driver will require a gang consisting of:

1 foreman,
1 engineman,
6 laborers,

and they should be able to unload and set up the driver in 3 days and dismantle and ship it in 2 days. This means that, regardless of the number of piles to be driven, the job must carry the cost of the full gang for 5 days. It must also carry the full fixed charge on the driver, which would probably be at least $25.00 per day, from the time it leaves the yard until it returns, and an additional charge for fuel and supplies, probably $10.00 for every active day.

In ordinary work, an average of 108 feet of piles can be driven per working hour but the character of the soil may be such as to reduce this figure by half.

If the total number of linear feet of piles be known, the number of hours required to drive them can thus be determined, and the cost computed.

An additional allowance of 1½ hours laborer's time per pile must be made for cutting off butts after driving.

CONCRETE PILES

As a general rule, no one but a concrete piling specialist should attempt to estimate on any concrete piling job, because practically all of that work is done by the owners of or licensees under one or another of a very limited number of patents.

However, if the operation is one for which precast piles may be bought and used, the cost of driving may be figured in the same manner as for wooden piles, except that a maximum of 50 feet per hour is all that can be driven.

CAISSONS

Here again we encounter a line of work that belongs strictly to the specialist and, though it might be practicable to get up figures covering a wide variety of conditions, it is

almost impossible to put them in such shape that they would be safe for use by any but experienced men.

However, for ordinary open caissons, for which the design has been prepared, the following method will prove satisfactory.

Estimate the cost of materials for building the caissons and the concrete for filling them, as explained in previous chapters.

Estimate the cost of building the caissons by the methods outlined in Chapters VII and VIII on Carpenter Work and add 50 per cent.

Estimate the cost of excavating by the methods outlined in Chapter II on Excavating and add 10 per cent, plus 1 hour laborer's time per cubic yard for hoisting.

Estimate the cost of mixing concrete in the usual manner, but add 50 per cent to the cost of placing it, plus 1 hour laborer's time per cubic yard.

CHAPTER XVI

CEMENT-GUN WORK

It is seldom practicable to apply Gunite in layers much over $\frac{3}{8}$ inch thick and it is, therefore, necessary to figure on as many coats, each $\frac{3}{8}$ inch thick, as will be necessary to build up the specified thickness, and also the necessary labor for finishing the final coat.

Scaffolds will have to be built for all operations that cannot be handled by a man standing on the floor or ground and their cost should also be figured as previously outlined.

For most cement-gun work the organization will consist of:

1 foreman,
1 nozzleman and helper,
3 laborers loading gun,
1 engineer,

while rental charges must be figured to cover the cement gun and the air compressor with its motive power and its fuel.

Such an organization can cover an average of 300 square feet per coat per hour and the additional cost of floating or otherwise finishing the final coat will be estimated on the same basis as that outlined for sand-finish plaster.

The material can be estimated by the table for an equivalent thickness of "top coat" in the section on plain concrete work and by adding 30 per cent to the quantity of sand, since that amount will be lost by sand rebounding from the surface to which the Gunite is applied.

Using the cement gun as a sand blast, with the same organization, about 100 square feet of steel or concrete surfaces can be cleaned in an hour and about 0.4 cubic yard of sand will be required per 100 square feet.

CHAPTER XVII

SHORT-CUT METHODS OF ESTIMATING

SECTION I. GENERAL

To the best of my knowledge, the methods of preparing preliminary estimates for mill buildings as outlined in this chapter, were first proposed by Charles T. Main, Engineer, of Boston, Massachusetts, in a paper which he presented at a meeting of the New England Cotton Manufacturers' Association, April 28, 1904.

The method outlined is vastly superior to any attempt to estimate contents by the square-foot or cubic-foot method and its greater accuracy well compensates for the added time required for its use.

The superiority of this method lies in the fact that it takes into consideration the variation in the ratio of floor area to wall area that takes place with every increase in the size of a building or any change in its shape.

An exaggerated comparison, but one that brings out forcibly the principle involved, is as follows:

Dimensions	Area	Length of wall	Ratio of length of wall to area of floor
1 by 1	1	4	4 to 1
100 by 100	10,000	400	4 to 100
2 by 1	2	6	3 to 1
200 by 100	20,000	600	3 to 100
3 by 1	3	8	2⅔ to 1
300 by 100	30,000	800	2⅔ to 100

However, like the "cubic-foot of contents" or "square-foot of area" method, the method given here is suitable only for approximate estimating and is not a safe method to use for bidding.

But, if this method is used with the proper care, always working out unit prices on the basis of up-to-date costs, there should be no trouble in quickly making an approximate estimate on any reasonably standard building and the estimate should fall within the range of the figures actually submitted in competition.

SECTION II. MILL-BUILDINGS

Assuming the following data as approximately the average, or standard, of mill-buildings in a given territory, we can proceed to set up a series of unit costs of a linear foot of wall construction and a square foot of floor or roof construction.

Floor timbers, 12 by 16, LLYP, 8–0 center to center.
Floor planking, 4 inches, LLYP, splined.
Roof planking, 3 inches, LLYP, splined.
Roof timbers, 8 by 14, LLYP, 8–0 center to center.
Roof covering, 5-ply tar and gravel.
Finished floors, 1 3/16 maple.
Floors on earth, 4-inch tar-rok, 3-inch hemlock plank and 1 3/16 maple, or 3-inch concrete base course and 1-inch top-coat.
Foundation, concrete, 4 inches thicker than wall it supports and 4–0 total height from top of footing to top of water table.
Footing course, concrete, 10 inches thick by width 8 inches greater than foundation course.
Story heights, 12–0 floor to floor.
Wall thickness, as per table.

TABLE 131

Height of building in stories	Thickness of brick walls in inches									
	Outside walls					Inside walls				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1	12	..	..	..	..	12				
2	12	12	..	..	..	12	12			
3	16	12	12	..	..	12	12	18		
4	20	16	12	12	..	16	12	12	8	
5	24	20	16	12	12	20	16	12	12	12

Now, assuming that we have found, by the methods outlined in previous papers, that we may use the following as average costs:

Bricks, delivered to the site, per thousand	$22.00
Mortar, per thousand bricks	4.00
Labor, per thousand bricks	26.00
Insurance, etc	2.60
Profit	5.40
Cost of bricks in walls, per thousand	$60.00

and allowing 21 bricks to the cubic foot, the cost per square foot of wall will be as follows:

TABLE 132

	Per Square Foot
8-inch wall	$0.84
12-inch wall	1.26
16-inch wall	1.68
20-inch wall	2.10
24-inch wall	2.52

and, therefore, a linear foot of all would be figured as follows:

TABLE 133.—UNPIERCED WALLS

Height of building	Outside walls	Inside walls
1 story	$ 15.12	$15.12
2 story	35.28	30.24
3 story	50.40	40.32
4 story	75.60	60.48
5 story	105.84	85.68

The figures just given are for unpierced walls, but most mill buildings have fairly large windows at regular intervals. Since steel sash are popular at present, let us consider that each 8-foot bay of the building is lighted by a standard steel sash Y-55-1-6-1.

The size of the opening is, therefore, 5 feet 2¾ inches by 7 feet 8¾ inches, or 40.4 square feet, and we will assume its cost to be

Sash	$ 8.50
Erection	2.50
Glass	12.50
Glazing and putty	3.00
Pointing	1.50
Stone sill and setting	4.00
Profit and insurance, etc	4.00
	$36.00

Since the bays are 8 feet 0 inches from center of window to center of window and the story heights are 12 feet, each bay, or panel, of wall will contain 96 square feet, consisting of

40.4 square feet of window and
55.6 square feet of brick work

from which we calculate that a bay of 12-inch wall would cost

For window, as before	$ 36.00
55.6 square feet wall @ 1.26	70.06
	$106.06

or practically $13.20 per linear foot.

Table 134.—Pierced Walls (Steel Sash)

Height of Building	Cost per Linear Foot of Wall
1 story	$13.25
2 story	29.43
3 story	42.68
4 story	61.77
5 story	83.68

A similar table can be prepared for varying lengths of bays and kinds and sizes of windows, and the estimator who has frequent occasion to furnish preliminary esti-

mates can well afford to utilize any spare time that he may have in preparing a series of such tables to cover the variety of conditions he most frequently encounters.

Foundations.—From the assumptions previously made, it is evident that the foundation sizes will be as follows:

Since the height of the footing and foundation courses is taken to be the same in all cases, we shall always require practically 10 square feet of forms to each linear foot of wall.

Assuming that, by the methods outlined in previous chapters, excavation, either back-filled or wasted, costs $1.00 per cubic yard.

Concrete, in place, costs $16.00 per cubic yard.

Forms cost 16 cents per square foot.

TABLE 135.—FOUNDATIONS

Building height	Footing course	Foundation course	Cubic yard concrete per linear foot	Cubic yard excavation per linear foot
(For outside walls)				
1	2–0 by 0–10	1–4 by 4–0	0.26	0.5
2	2–4 by 0–10	1–8 by 4–0	0.32	0.55
3	2–4 by 0–10	1–8 by 4–0	0.32	0.55
4	2–8 by 0–10	2–0 by 4–0	0.39	0.6
5	3–0 by 0–10	2–4 by 4–0	0.44	0.65
(For inside walls)				
1	2–0 by 0–10	1–4 by 4–0	0.26	0.5
2	2–0 by 0–10	1–4 by 4–0	0.26	0.5
3	2–0 by 0–10	1–4 by 4–0	0.26	0.5
4	2–4 by 0–10	1–8 by 4–0	0.32	0.55
5	2–8 by 0–10	2–0 by 4–0	0.39	0.6

we can construct another table, as follows; allowing for profit and insurance.

TABLE 136.—COST OF FOUNDATION

Building height	Per linear foot outside walls	Inside walls
1	7.15	7.15
2	8.30	7.15
3	8.30	7.15
4	9.65	8.30
5	10.60	9.65

Floor Constructions.—Floors resting directly upon the earth will not have any parts of the structural frame included in their cost, but must bear all of the cost of removing top-soil, grading, cinder or gravel fill, or similar items.

Assuming the square of 100 square feet as the basis of calculation for this type of floors, we may use the following figures:

Concrete Floor:	
Excavating top-soil 3.7 cubic yards @ $1.00	$ 3.70
Levelling sub-grade	2.00
2.09 barrels cement @ $3.20	6.69
0.70 yards sand @ $1.50	1.05
0.85 yards gravel @ $2.50	2.13
Labor on base and top courses	9.0
Insurance and profit	3.0
Cost per square	$27.57
or, 28 cents per square foot.	
Tar-Rok, Hemlock and Maple Floor:	
Including grading sub-let for about	$15.00
300 FBM hemlock plank @ $45	13.50
Labor placing plank	3.00
Floor paper	0.50
130 FBM maple @ $90 per M	11.70
Labor placing maple	4.00
Nails, etc	0.50
Insurance and Profit	5.00
Cost per square	$53.20
or, practically, 54 cents per square foot.	

Floor constructions, as well as roof constructions, which are supported by the structural frames must bear the cost of their share of the structural frame, and it therefore becomes easier to figure the cost on the basis of the bay or panel, instead of the square.

In order not to make our list of units unduly complicated we will make certain assumptions which, while not absolutely true, give fairly close results.

We will assume the spacing of beams to be 8 feet 0 inches center to center, the spacing of columns longitudinally to be 18 feet 0 inches center to center, the average column to be 10 by 10, 12 feet 0 inches long, the average share of column footing to each story to be equal to one 24 by 24 by 18 footing.

Then, for one bay, we must allow

0.9 cubic yard excavation	@ $1.00	$ 0.90
0.23 cubic yard concrete	@ 16.00	3.68
12 square feet forms	@ 0.16	1.92
1 10 by $^{10}/_{12}$–0 column,	100 FBM	
1 12 by $^{16}/_{18}$–0 beam,	288 FBM	
4-inch plank,	662 FBM	
	1,050 FBM average 70.00	73.50
Miscellaneous iron, pintles, etc., 200 pounds		10.00
Splines 216 linear feet @ 1 cent		2.16
Nails and paper		1.50
Labor on timber @ $18.00		6.90
Labor on plank @ $4.00		5.76
167 FBM maple @ $90.00		15.03
Labor placing maple		5.76
Insurance and profit		20.00
Cost per panel of 144 square feet		$147.11

or practically $1.03 per square foot.

For the roof construction, we would allow the same figures for the first three items, but must take into consideration the over-hang of the roof and the cost of the cornice.

Since the corner panels of the roof carry over-hang and cornice on two sides, while the center panels do not carry either, we are safe in figuring each panel as though it carried

an 18-inch over-hang and full cornice on one side, which also means that our timber must be figured as 20 feet long; thus,

Excavation, concrete, forms		$ 6.50
Column,	100 FBM	
1 8 by $^{14}/_{20}$ beam,	187 FBM	
3-inch plank,	552 FBM	
	839 FBM @ $70.00	58.73
Misc. iron (hangers, etc.)		10.00
Splines, nails, etc.		2.60
Labor on Timber @ $18.00		5.16
Labor on plank		5.76
Roofing (sub-let for $15.00 per square)		21.00
Insurance and profit		14.00
Cost per panel		$123.75

or, practically 86 cents per square foot of building, disregarding the overhangs.

Miscellaneous Items.—By the usual methods, we may estimate the cost of such items as flights of stairs, and find that the average will be about $180 per flight for ordinary mill stairs and $235 per flight for an outside iron fire-escape.

From previous experience, we can determine an average cost per fixture for the plumbing, and this will probably be about $100.

Painting costs vary widely, depending upon the amount of work that is required and the kinds of materials to be used, but an allowance of 5 per cent of the combined costs of the mason and carpenter work will be sufficient for a preliminary estimate.

Ornamental stone trim, tile floors and similar items should be figured on the basis of prices paid for similar recent jobs and added to the figures determined according to this method.

Profit and insurance have already been included, but an additional allowance of 10 per cent should be added to

the estimate to include any incidentals that would otherwise be overlooked.

Assuming that a request has been received for a preliminary estimate to cover a cotton mill. It is to be five-stories high, to be of standard mill-construction and is four hundred feet long, sixty feet wide, divided by a cross wall at the middle of the length and each end of each floor has a stair enclosure 12 by 16 feet and a toilet room enclosure of the same size, with six fixtures in each.

The length of the outside walls is evidently 920 feet, the length of the inside walls is

	Feet
Cross walls	60
Partition walls (4) by 28	112
	172

ESTIMATE

1.	172 linear feet Fdtn of 5-story inside wall @ $9.65	$ 1,659.80
	920 linear feet Fdtn of 5-story outside wall @ $10.60	975.20
2.	172 linear feet 5-story inside wall @ $85.68	14,736.96
	920 linear feet 5-story outside wall @ $83.68	76,985.60
3.	24,000 square feet tar-rok, hemlock and maple floor @ $54	12,960.00
4.	96,000 square feet standard floor @ $1.03	98,880.00
5.	24,000 square feet standard roof @ $80	20,640.00
6.	Painting 5 per cent of items 2–3–4–5	11,210.10
7.	Stairs 8 flights @ $180	1,440.00
8.	Plumbing 60 fixtures @ $100	6,000.00
9.	Contingencies	25,986.00
	Total	$271,473.66

which equals $2.26 per square foot of floors or $0.188 per cubic foot of building. If the principal units have been correctly calculated upon the basis of current prices, the figure should invariably come between the highest and lowest figures submitted when the plans are sent out for actual competitive bids.

SECTION III. REINFORCED CONCRETE BUILDINGS

Reinforced concrete buildings generally fall into one of two general types, flat-slab construction and beam and girder construction but, because the flat-slab construction is rapidly superseding the other type for industrial buildings, we will only attempt to draw up figures for the first type.

There are several different "systems" of flat-slab construction, but for equal spans and equal loadings the costs do not vary a great deal, so only one set of figures will be needed for preliminary estimating.

The two important factors governing the costs of reinforced concrete factory buildings are the live floor load, which determines the slab-thickness and percentage of steel, and the column spacing

Column spacings vary appreciably but a dimension of 20 feet 0 inches center to center is sufficiently standard to warrant its use in determining slab-thicknesses and steel-percentages, and from them the approximate costs per square foot of slab.

From the "Concrete Designers' Manual," by Hool and Whitney (McGraw-Hill Book Company, Inc., New York City), we get the following quantities of steel and concrete for slabs (including drop-heads), designed according to the recommendations of the American Concrete Institute.

TABLE 137.—FLAT SLAB FLOORS

(Panel size 20 by 20 feet)

Live load per square foot, pounds	Concrete per square foot, cubic foot	Reinforcing steel per square foot, pounds
100	0.65	2.53
150	0.65	3.27
200	0.70	3.70
250	0.74	4.00
300	0.81	4.30
350	0.86	4.55

TABLE 138.—AVERAGE SIZES OF COLUMNS

Height of building in stories	Diameters of interior columns					Thickness of exterior columns (width assumed 16 inches)				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1	12	..	..	..	..	12				
2	14	12	..	..	..	12	12			
3	16	14	12	..	..	14	12	12		
4	18	16	14	12	..	16	14	12	12	
5	20	18	16	14	12	16	16	14	12	12

NOTE.—In actual designs the column sizes would vary with changes in load and a tabulation might well be made of column dimensions and steel areas for each floor loading given above, but for the purpose of illustrating the method, one set of figures will suffice.

For the purposes of preliminary estimating we can assume that each column base will require the following quantities:

Since the side walls carry no load, the wall footings need only be strong enough to support the first-story walls and they will also serve to prevent frost from working under the floors.

We therefore assume a footing wall, 12 inches thick and 4 feet 0 inches high running around the building between the wall column foundations.

Each story will be assumed to have an 8-inch brick curtain wall, 3 feet 0 inches high, cement sills, and steel sash from sill to spandrel beam of slab above.

The top story will also have a parapet wall 3 feet 0 inches high with cement coping.

Assuming that we have found by previous calculation

TABLE 139.—COLUMN FOUNDATIONS

	Concrete, cubic yards	Forms square, feet	Steel, pounds	Excavation, cubic yards
5-story wall column	1.2	44	171	4.0
4-story wall column	1.1	44	130	4.0
3-story wall column	1.0	41	90	3.3
2-story wall column	0.7	39	60	3.0
1-story wall column	0.7	39	50	3.0
5-story interior column	3.1	60	294	9.0
4-story interior column	2.3	52	216	7.1
3-story interior column	2.1	44	150	5.5
2-story interior column	0.9	28	96	2.5
1-story interior column	0.7	20	54	1.9

that the prices used are correct for existing markets and local conditions, we may proceed to set up our table of unit prices as follows:

Cost of floor slab for 150-pound live load:

0.65 cubic feet = 0.024 cubic yard concrete @ $16	$0.384
1 square foot forms	0.20
3.27 pounds steel @ $0.05	0.164
Granolithic finish	0.062
Insurance and profit	0.10
Cost per square foot	$0.91

Cost of roof slab:

0.24 cubic yard concrete @ $16	$0.384
Forms	0.20
2.53 pounds steel	0.127
5-ply roof	0.15
Insurance and profit	0.099
Cost per square foot	$0.96

Cost of 5-story interior column:

9 cubic yards excavation @ $1	$ 9.00
60 square feet fronting forms @ $0.20	12.00
7 cubic yards concrete @ $16	112.00
60 linear feet column forms @ $1.50	90.00
942 pounds steel @ $0.05	47.10
Insurance and profit	35.90
	$306.00

Cost of 1 linear foot of exterior wall:

0.4 cubic yard excavation @ $1	$ 0.40
0.15 cubic yard fronting concrete @ $16	2.40
8 square feet fronting forms @ $0.20	1.60
18 square feet 8 inch brick wall @ $0.84	15.12
5 linear feet sill @ $1	5.00
1 linear foot coping @ $1.50	1.50
40 square feet windows @ $0.80	32.00
Insurance and profit	7.38
	$65.40

Cost of one 5-story exterior column:

4 cubic yards excavation @ $1	$ 4.00
416 cubic feet forms @ $0.20	83.20
4.3 cubic yard concrete @ $16	68.80
570 pounds steel @ $0.05	28.50
Insurance and profit	22.50
	$207.00

Note.—We count corner columns as two wall columns each and deduct the wall columns to determine the total length of wall.

Now, suppose that the inquirer who asked for the estimate on the mill building wanted to know what a building of the same size, but of reinforced concrete in the construction just discussed, would cost.

Estimate:

1.	38 interior columns @ $306	$ 11,628.00
2.	50 exterior columns @ $207	10,350.00
3.	853 linear feet outside walls @ $65.40	55,786.20
4.	10,320 square feet 8-inch brick inside walls @ $0.84	8,668.80
5.	24,000 square feet concrete first floor @ $0.28	6,720.00
6.	96,000 square feet reinforced floors @ $0.91	87,360.00
7.	24,000 square feet reinforced roof @ $0.96	23,040.00
8.	Painting	10,200.00
9.	Stairs, 8 flights @ $300	2,400.00
10.	Plumbing, as before	6,000.00
11.	Contingencies	22,215.00
	Total	$244,368.00

which equals $2.04 per square foot of floors or 17 cents per cubic foot which is less than the cost of the mill buildings, on the basis of the figures used.

This same method can be carried out for any type of work. A set of figures might easily be made up covering side-walls, floors, partitions and roofs of houses, but it must always be remembered that the figures reached are approximate only and that their value, even for that purpose, depends upon the care with which they are compiled and the correctness of the prices used.

CHAPTER XVIII

SUMMARY

SECTION I. SUB-BIDS

A diligent study of the preceding chapters should give the student a grasp of all the subjects covered, and with a reasonable amount of practical experience, he should be prepared to do all of the estimating usually required in the office of a general building contractor.

It is true that there are many building contractors who make a practice of taking every item in detail from the plans, even though it is their practice to sub-let a great deal of the work, but it is believed that it is easier and safer always to get reliable sub-bids on every item that will eventually be sub-let.

Of course, in cases of emergency, when no sub-bids are available, the builder must be prepared to estimate many items of sub-contractors' work. Even so, it is well to remember that, no matter how complete his knowledge of the subject may be, the man actually engaged in a particular line has much greater opportunities for keeping up to date than any builder has, both as regards labor and material prices and conditions in the trade. Furthermore, if the sub-bidder is reliable, his figure will stand and relieve the general contractor of any further concern as to its correctness.

On the other hand if he always deals fairly with all of his sub-bidders, he will find very few occasions when he will not be able to get all the sub-bids he needs.

Needless to say, fairness requires that a sub-bidder, whose figure is used to make up a successful bid, should be awarded the sub-contract without further question and without "dickering."

The practice of "shopping around" after a contract has been awarded, in order to let sub-contracts at lower figures than those of the sub-bidders whose figures were used, is a very pernicious one, besides making the sub-bidders suspicious of all general contractors, encourages them to add large percentages to their figures for the sole purpose of "knocking off" later on.

Thus, a general contractor who is known to be a "shopper" may lose valuable opportunities because all the sub-bids he receives will be so high as to throw his own bid out.

If a contractor must shop around after receiving contracts, then he should estimate every item himself and take his own chances of being able to sub-let for less than his estimate.

The methods to be used in getting sub-bids will vary with the size of the job, location, and local conditions.

When competition for the general contract is fairly open, as in the case of most public buildings, plans will be on exhibition at all of the general contractors' offices and all sub-bidders will have access to them at one office or another.

In such instances it is only necessary to send out postal card requests to the several sub-bidders who are known to be actively interested in the lines of work to be included.

On small jobs, or jobs for which the competition is more restricted, it is usually necessary to invite sub-bids from people with whom the builder usually deals and sometimes to take the plans and specifications to them.

SECTION II. VISITING THE SITE

In the discussion of the cost of excavating, we gave a list of information to be obtained when visiting the site of any work upon which a bid is being made.

In addition to the items mentioned there, be sure to get the local prices on any materials available for use in the work, costs of carting, sub-bids from nearby bidders when possible, and information as to any local rules or regulations which may have a bearing upon the figures.

Many architects and engineers put clauses in contracts that require the builder to comply with all local regulations, even though not recited in the specifications.

Such a clause as this might make the sidewalk-protection, or even the working staging, cost twice as much as would otherwise be figured; it might make it necessary to put an extra coat of paint on the steel-work, or an extra coat of plaster on the walls and ceilings, or do a lot of expensive fire-stopping that had not been considered at all.

There are also rules regarding the use of streets and alley-ways that may affect costs and, in times of labor shortages, the fact that another large operation is going on nearby may cause labor costs to mount high, either through increased wages or decreased production.

The availability of and rates at suitable boarding places will also affect the readiness of men to go to a given location, and it may be necessary at times to provide quarters and commissary for them. It is a very rare occurrence when a job commissary pays its own cost, so the loss on the commissary must be figured as part of the cost of doing the work.

SECTION III. MAKING UP THE ESTIMATE

The number of different forms used for estimating is almost as great as the number of contractors who make estimates. Some use stock forms, some use specially ruled and printed forms, some use loose sheets and some use books.

Some contractors combine the unit labor and material prices before multiplying by the quantity, but I prefer to keep a separate column of labor costs and one of material costs.

One construction company, with which I was associated for a time, used a book made up of quadrille-ruled sheets with a dollars-and-cents column at the right and left hand sides of each page, one book of about thirty pages being used for each estimate.

The "take-off" or survey of quantities was made in the middle of the page and extended to totals for each subject.

After calculating the unit labor and material prices for each item, the extension of the labor-cost was made into the left hand column, and that of the material cost was made into the right hand column, all the prices on each side which made up any sub-head of the estimate were then added up, a double blue-pencil line ruled under each total, and it transcribed onto the summary page.

The summary might appear something like this:

Name of Job
Location
Architect or Engineer Date

Labor		Materials
$ 1,500.00	Preliminaries (page 3)..............	$ 500.00
1,925.00	Excavation and grading (page 5)....	....
2,750.00	Concrete and forms (page 9)........	3,950.00
5,675.00	Brickwork (page 12)...............	9,250.00
....	Plastering (sub-bid), (page 13)......	5,500.00
1,800.00	Rough carpentry (page 15)..........	3,650.00
2,230.00	Finish carpentry (page 17)..........	4,575.00
....	Roofing and sheet-metal work (sub-bid) 18...........................	1,550.00
....	Plumbing (sub-bid) 19.............	2,500.00
....	Heating (sub-bid) 20...............	5,000.00
....	Wiring (sub-bid) 21................	900.00
....	Allowances.......................	500.00
$15,880.00		$37,875.00

Total labor......................	$15,880.00
Materials.......................	37,875.00
	$53,755.00
10 per cent profit.................	5,375.00
Bid...........................	$59,130.00

Such a method has the advantage of not carrying a running total, from page to page, and it is thus possible to

make changes or corrections in any page without having to erase the total on all of them.

As a check, to be sure that all sub-totals are carried into the summary, all the blue-underlined figures should be added together directly from the individual sheets to see that they equal the total in the summary.

It has been found helpful to recapitulate all totals thus:

		Per cent
1. Preliminaries.	$ 2,000.00	3.7
2. Direct labor.	14,380.00	26.7
3. Materials.	21,425.00	40.0
4. Sub-bids.	15,450.00	28.7
5. Allowances.	500.00	0.9
	$53,755.00	100.0

This recapitulation affords an opportunity to compare the relation which the various portions of the present estimate bear to previous estimates and sometimes to show up a difference that might otherwise be overlooked.

It is also helpful in cases of very sharp competition where the bidder might want to figure a smaller percentage of profit on such certain items as sub-bids and allowances, but to retain the full percentage on such items as labor.

In making up the estimate, when a sub-bid is used, it is customary to write in the name of the sub-bidder, together with any pertinent information, on one of the pages of the estimate, and then carry the figure into the summary in the same manner as any other figure but to make a notation as indicated.

If you do not care to use a specially ruled form, ordinary journal paper, which has two sets of dollars-and-cents columns on the right hand side, can be used just as well, one column being used for labor items and the other for materials and sub-bids.

SECTION IV. REMINDER LIST

Some contractors use a reminder sheet, containing a list of items usually entering into the construction of buildings such as the one included here, and the estimator may check off the item as he figures it.

These reminder lists are helpful, but they have the disadvantage that it is practically impossible to prepare one that will be complete, and also that an estimator might depend too much upon the list and neglect to scan the plans and specifications carefully for little notes and inconspicuous clauses.

Summary of Estimate

Building Date
Location
Architect
Stories in height Ground area
Floor area Contents
(See Sheet 2 for dimensions and calculation)

	Sheet	Labor	Materials
General conditions			
Excavation, earthwork, drains			
Plain concrete work, inc. forms			
Reinforced concrete work, inc. forms			
Brickmason's work			
Furring, lathing, plastering			
Millwork and trim, screens, weatherstrips			
General carpenter work (except forms)			
Kalameined and metal windows and doors			
Storefronts and plate glass			
Structural steel, ornamental and miscellaneous iron, bronze			
Iron and steel bucks, trim and specialties			
Lockers, cabinets, metal partitions			
Linoleum, rubber, cork, etc			
Terrazzo, marble, tile, slate			
Roofing and sheet metal work			
Elevators, dumbwaiters, lifts			
Waterproofing and damp-proofing			
Demolition and shoring			
Plumbing, heating, ventilating, sprinklers			
Wiring, fixtures, clock systems			
Painting and decorating			
Totals		$	$

Recapitulation

General conditions	
Ordinary payroll	
Allowances	
Materials	
Construction subs	
Mechanical subs	
Estimated net cost................	$
Estimated profit..................	$
Recommended bid................	$

GENERAL CONDITIONS

	Labor	Materials
Pay for plans, extra blue prints, etc......		
Bond..............................		
Liability and compensation insurance.....		
Fire insurance......................		
Superintendent......................		
Timekeeper.........................		
Watchman..........................		
Job engineer........................		
Temporary buildings and toilet..........		
Temporary light and heat..............		
Temporary enclosures.................		
Survey and batters...................		
Permits and fees....................		
Use of tools and equipment.............		
Transp of tools and equipment..........		
Small tools.........................		
Sidewalk protection..................		
Photographs........................		
Sampling and tests...................		
Clean and remove rubbish..............		
Water for building purposes............		
Telephone service and tolls............		
Travelling expense...................		
Totals............................		

Excavation, Earthwork, Drains

Clear site.
Remove and protect trees and shrubbery.
Build fences, roads, ramps.
Scrape loam.
General excavation and disposal of spoil.
Trench and pier excavation.
Wet excavation and pumping.
Drilling, blasting and rock excavation.
Backfilling.
Sand, gravel or cinder filling.
Agricultural or Akron tile drains.
Manholes and catch basins.
Cesspools and dry wells.
Excavation for service connections and for other trades.
Rough grading.
Finish grading.
Sodding, seeding and planting.

Plain Concrete Work

Concrete footings and walls.
Piers and steps.
Floors, walks, drives, curbing.
Thresholds, sills, coping, caps.
Dressing exposed surfaces.
Granolithic finish.
Hardening and special finishes.
Curb bars.
Forms for concrete.
Integral waterproofing.
Sleeper filling and roof grading.

Reinforced Concrete Work

General and special mixes.
Wall and column footings, walls, columns, beams, girders, spandrels, floor and roof slabs.
Stairs.
Integral and applied finishes.
Ornamental work, sills, lintels, pilasters, columns, coping, balusters, rails.
Steel and wood forms.
Reinforcing rods, mesh, lath.

Stationary or removable pans and domes.
Chairs, ties, inserts, sleeves and accessories.
Trimmer arches.
Protecting structural steel.
Grouting columns, bases and lintels.
Set up and take down concreting plant.

Brickmason's Work

Common, hollow, face, fire, paving, enamelled, glazed, ground or moulded bricks.
Culling bricks.
Brick hearths and facings.
Cleaning, pointing, oiling.
Wall ties and plugs.
Interior and exterior scaffolding.
Brick veneering.
Parging.
Boiler setting.
Hollow tile walls, backing, floor construction, partitions, roofing, furring, column-, beam- and girder-covering.
Glazed tile walls and partitions, special shapes.
Cement, cinder or slag blocks.
Flue linings.
Chimney pots or caps.
Firestopping.
Rubble masonry.
Cut granite, blue stone, limestone, sand stone, marble.
Cast stone.
Stone paving and flagging.
Architectural terra cotta.
Tile inserts.

Furring, Lathing, Plastering

Metal furring on walls and ceilings.
Metal lath, stapled, wired or clipped to supports.
Lathing for solid partitions.
Wood lathing.
Gypsum board lathing.
Fiber board lathing.
Corner beads and cornerite.
Two- and three-coat plastering.
Special finishes and textures.

Keene's cement work.
Caenstone work.
Scagliola.
Portland cement stucco.
Magnesite stucco.
Ornamental work cast in shop.
Ornamental work run in place.
Modelling.
Scaffolding.
Patching after other trades.

Millwork and Trim, Screens, Weatherstrips

Exterior finish, cornices, columns and pilasters, watertable, corner boards, dormer trim.
Interior finish, door and window jambs and trim, base, chair-rail and picture mould, panelling, beam casings, wainscoting, stairs.
Cabinet work.
Access panels.
Wardrobes.
Closets and cedar linings.
Folding partitions.
Folding stairs.
Store front work, counters, shelving.
Flag poles.
Blackboards, bulletin boards and trim for same.
Radiator enclosures.
Wood or metal screens.
Weatherstrips.
Window shades.

General Carpenter Work

Scaffolding for other trades.
Jobbing for other trades.
Grounds, sleepers and screeds.
Wall and ceiling furring.
Miscellaneous blocking and furring, wood bricks.
Door bucks.
Protect stone work.
Framing of floors, walls, roofs, dormers, partitions.
Boarding of walls, floors and roofs.
Siding, clapboarding, shingling.

Insulating.
Finish floors.
Parquetry.
Nails and rough hardware.
Paper, felt and quilting.
Finish hardware.
Temporary floors and stairs.
Firestopping.

Kalamein and Metal Windows and Doors

Hollow metal doors and windows.
Kalameined doors and windows.
Smoke screens.
Underwriters' doors.
Fire shutters.
Metal access doors and panels.
Overhead doors.
Hatchway doors.
Steel rolling doors.
Bronze doors.
Vault doors.
Steel cellar sash.
Steel factory type sash.
Steel monitor sash.
Steel projected windows.
Steel casement windows.
Steel double hung windows.
Screens.
Operating devices.
Special hardware.

Storefronts and Plate Glass

Metal covered work.
Drawn metal work.
Special finishes.
Ventilating devices.
  Jambs.
  Sills.
  Muntins.
  Transom bars.
Polished plate glass.

Special transom glass.
Art and leaded glass.
Mirrors.
Glass for steel sash.
Glass for doors, etc.

Structural Steel, Ornamental and Miscellaneous Iron, Bronze

Structural steel.
  Erection.
  Rivetting.
  Welding.
  Painting.
Cast iron.
Concrete filled columns.
Miscellaneous bolts and anchors.
Stairs.
Railings.
Fire escapes.
Balconies.
Gratings.
Finials
Stable fittings.
Pipe railings.
Ladders.
Safety treads.
Door and window guards.
Woven wire work.
Column guards.
Bank and vault work.
Jail and cell work.
Revolving doors.
Ash hoists and sidewalk doors.
Vault lights and frames.
Fireplace throats, ash dumps and clean out doors.
Manhole and cesspool covers.
Coal chutes, garbage and package receivers.
Steel joists and bridging.
Nailer joists.
Steel decking.

Iron and Steel Bucks, Trim, Specialties

Steel bucks.
Steel trim, base, picture moulding, capping.

Lockers, Cabinets, Metal Partitions

Steel lockers.
Steel shelving and bins.
Built-in steel furniture.
Medicine cabinets.
Steel toilet partitions.
Steel shower partitions.
Steel office partitions.

Linoleum, Rubber, Cork

Treads.
Floors.
Moulded bases.
Wainscots.
Thresholds.
Nosing strips.
Cork bulletin boards.
Cork insulation.

Terrazzo, Marble, Slate, etc.

Floors.
Wainscots, base, cap rails, trim.
Moulded specials.
Dividing strips.
Stairs and nosings.
Balustrades.
Sills and nosings.
Borders and panelling.
Garden and hall furniture.

Roofing and Sheet Metal Work

Composition roofing.
Tar and gravel roofing.
Asphalt roofing.
Asbestos roofing.
Metal roofing.
Canvas roofing.
Slate roofing.
Plastic slate roofing.
Tile roofing.
Guaranty.
Insulation under roofing.
Roof water outlets, gutters, conductors.

Flashing, ridging.
Snow guards, finials, weather vanes.
Cornices, spandrels and ornamental work.
Skylights.
Interior sheet metal work.
Laundry chute.
Stamped metal ceilings.

Elevators, Dumbwaiters, Lifts

Elevators and enclosures.
Automatic elevators.
Coin elevators.
Plate drops.
Dumbwaiters.
Sidewalk elevators.
Mail chute.
Fuel lift.
Differential hoists.
Escalators.
Greasing lifts (for garages).

Waterproofing and Dampproofing

Integral compounds (unless included in concrete).
Membrane waterproofing.
Applied coats of waterproofed concrete or mortar.
Applied dampproofing.
Tar concrete work.
Tarred sand levelling course.
Caulking.

Demolition and Shoring

Tearing out present construction.
Supporting present construction.
Underpin and protect adjoining structures.
Sheet piling and bracing banks.

Plumbing, Heating, Ventilating, Sprinklers

Permits and fees.
Service connections.
Cesspools (if in plumbing contract).
Water supply, pumps, wells, tanks.
Water closets, urinals, sinks, lavatories.
Bidets, lavatories, drinking fountains, baths, showers, foot baths.

Thermostatic valves.
Soil and waste piping, traps, vents.
Domestic boilers.
Refrigerator drains.
Floor and roof drains.
Cellar drainer.
Boilers.
Single or double piping.
Valves, air-valves, checks, gauges.
Return pump.
Radiators.
Expansion tank.
Stoker and ash remover.
Oil burners.
Air washers or humidifiers.
Ventilating ducts or units.
Dampers, registers, grilles.
Insulating piping and boiler.
Bronzing pipes and radiators.
Gas piping.
Range, water heater, storage, refrigerator.
Sprinkler system.
Storage and pressure tanks.
Alarm valves.
Fire hose reels.
Fire curtain.
Fire stand pipes.

Wiring, Fixtures, Clock Systems

Service connections.
Meter and panel boards.
Transformers.
Wiring and conduits.
Switches, light and power outlets, floor and wall plugs.
Connections to heating and ventilating system.
Lighting fixtures.
Bell, annunciator and speaking tube systems.
Interior phone systems.
Conduits for telephone wiring.
Radio wiring.
Electric clocks, program clocks and master clock systems.
Refrigerators, ranges.

Vacuum cleaner systems.
Oil burner connections.
Lighting protection.

Painting and Decorating

Back painting and priming.
Exterior painting.
Interior painting.
  Staining, filling.
  Varnishing.
  Kalsomining.
  Waxing.
  Canvas and burlap.
  Papering.
  Decorating.

Special Items

Diving.
Boring.
Caisson work.
Sub-aqueous foundations.
Piling, wood, steel or concrete.
Cold storage work.
Coal handling equipment.
Cash carrier systems.
Package conveyors and carrier systems.
Kitchen equipment.
Laboratory equipment.
X-ray equipment.
Hospital equipment.
Restaurant equipment.

SECTION V. PRELIMINARIES AND OVERHEAD ITEMS

Among the most difficult items to calculate correctly in a building estimate, are some of the items usually included as overhead or preliminaries.

This is because many of them, such as

Superintendent's salary
Timekeeper's salary
Watchman's salary
Temporary heat and
Commissary loss

are dependent entirely upon the length of time occupied in constructing the building, rather than upon the quantities of materials involved.

In previous chapters the method to be used in calculating the cost of the foreman for a given item of the work has been indicated, practically the same method must be used to figure the total time required to complete the entire structure, making due allowance for the time when two or more parts of the work will proceed concurrently, in order to calculate the salaries of superintendent, timekeeper, clerks and watchman with any degree of accuracy and even then unforeseen delays will often spoil all the calculations.

Such items as office building, sheds, storehouses, sidewalk, bridges and fences, are best figured by making little pencil sketches of them and calculating the labor and materials involved.

If portable office buildings are used, it is only necessary to figure the transportation; and if standardized sheds are developed the problem will be just that much simpler.

The premium on a surety-bond is always a fixed percentage (usually 1½ per cent) of the total amount of the contract, regardless of whether the indemnity is 25 or 100 per cent of the contract.

Insurance is figured on the payroll, as indicated in previous chapters, and the rates vary but are always included in the policies, so that they can readily be determined.

SECTION VI. EQUIPMENT

Even if a builder owns his equipment, it is constantly being worn out or becoming obsolete, so he is entitled to figure into his estimate an amount which would enable him to keep it in repair, to retire his investment or replace his equipment as needed and to make a reasonable profit on his investment.

Rental rates vary greatly, some contractors figure a flat charge per day or week from the time equipment leaves the storehouse until it returns, others have one rate for

active time and another for idle time, but in all cases, transportation both ways should be included.

A typical equipment rental list follows:

Terms of Rental Charges and What Tools Are Supposed to Include

1. Where prices per week are not inserted they are indefinite and are subject to special agreements.

2. No tools are to be rented for less than one week unless special agreement.

3. Tools and machinery are to be shipped from jobs or storehouses in good repair and complete with parts and fittings ready to run, and are to be returned to other jobs or storehouses in good repair, allowing for reasonable wear and tear. If necessary to buy parts at the job to make the tools or machinery ready to run, same is to be charged to user. (Tool and Maintenance Account.) The jobs to pay the expense of repairs or breakage while on their job.

4. The jobs to pay for transportation both ways.

5. On all contracts, the rental of tools or machinery to commence when they are set up and ready to run, and to continue, until they are taken down or shipped, unless we are notified by the user's representative that they are no longer needed in which case the rental stops on the day of notification.

Rental charges on tools and machinery to other than our own jobs to commence when they are taken from storehouses or jobs and to continue until returned, unless otherwise agreed.

6. Stone crushers are to be complete with elevator and screen. Bins for large crushers to be furnished by the job. Portable bins on separate rental. Motive power on separate rental. We are to replace worn-out jaws with new.

7. Steam or air drills to have 15 feet of hose and to be replaced by us when worn out. Drills to be kept in repair at the jobs. Drill steel to be charged to the job and taken back at its market value at the close of the job.

Description	Rent per week	Description	Rent per week
		Concrete mixer, ¼ yard	$15.00
Derrick 40 to 60 feet	$12.00	Bantam mixer with gas engine	12.00
Derrick 60 to 90 feet	15.00	Concrete carts	1.00
Stiff-leg derrick	12.00	Scale box iron	2.00
Hand derrick, small	5.00	Scale box wood	1.00
Hand derrick, large	8.00	Circular saw table	2.00
Breast derrick	2.00	Band saw	1.00
Wheel derrick	2.00	Buzz planer	1.00
Four-leg derrick	2.00	Six-foot swing saw	1.00
Gin poles	2.00	Chain hoists 2 or 3 ton	3.00
Hoisting engines 3D	18.00	Chain hoists 5 ton	4.00
Hoisting engines 2D	13.00	Barrett jacks	1.00
Hoisting engines 1D	8.00	Screw jacks	0.50
Skeleton engines 3D	11.00	Albany jacks	1.00
Skeleton engines 2D	9.00	Norton jacks	1.00
Skeleton engines 1D	5.00	Bed-screw jacks	0.50
Flat car, 24-inch and 36-inch gauge	2.00	One-horse, 2-wheel dump carts	
Koppel car	2.00	Two-horse, 4-wheel wagons	3.00
1½-yard 2-way dump car	3.00	"Chocolate drop"	10.00
4-yard dump car	4.00	Quarry bar	10.00
Dray, 10 ton	10.00	Quarry bar, 4-inch, 2½-inch	
Pile driver	......	Elevator platform, small	1.00
Steam sheet pile hammer, 4-inch	9.00	Steam sheet pile hammer, 6-inch	$12.00
Bolt cutting machine	1.00	Timber dollies	0.50
Pipe cutter	1.00	Timber truck, 2-wheel	0.50
Gas cutting machine	6.00	Truck, 4-wheel	2.00
Blacksmith kit and forge	1.50	Air compressors, 8 inches by 8 inches	15.00
Riveting kit and forge	1.50	Air compressors, 22 inches by 13 inches by 16 inches	40.00
Cableways 1,000 feet	60.00	Air compressors, 19 inches by 12 inches by 16 inches	35.00
Hand-drills, press	0.50	Lights, carbic	1.50
Rock-drills, tripod	10.00	Winch	2.50
Jack hammer drills	6.00	Industrial R. R.	
Electric boring drills	5.00	Electric motors, 5 horsepower	
Ratchet drills	0.50	Electric motors, 10 horsepower	
Concrete mixer, ⅓ yard	25.00	Pump, 10-inch discharge, belted	10.00
Concrete mixer, ¾ yard	22.00	Pump, 8-inch discharge, belted	8.00
Concrete mixer, ½ yard	20.00	Pump, 6-inch discharge, belted	6.00
Independent swingers	5.00	Pump, 6-inch discharge	12.00
Locomotive boilers, 50 horsepower	15.00	Pump, 5-inch discharge	10.00
Vertical boilers, 18 horsepower	7.00	Pump, 4-inch discharge	8.00
Vertical boilers, 20 horsepower	12.00	Concrete surfacer	8.00
Stone crushers, 9 by 16 inches	20.00	Power grindstone	1.00
Stone crushers, 24 by 13 inches	30.00	Rowell chimney hoist	5.00
Stone crushers, 20 by 10 inches	25.00	Portable houses	3.00
Stone crushers, 28 by 12 inches	40.00	Lead furnace on wheels	2.00
Stone crusher bin, portable, 30 ton	6.00	Staging clamps	0.02
Cement gun	30.00	Putlogs patent	0.04
Blasting battery	2.00	Plow, root, six-horse	4.00
Concrete dump carts	2.00	Plow, root, four-horse	3.00
Clamshell buckets	10.00	Punch, hand-screw	1.00
Orange peel buckets	10.00	Rod bender	1.00
Concrete spouting outfits		Ram, hydraulic	1.00

Description	Rent per week	Description	Rent per week
Roofer's kit	5.00	Pump, 12-inch discharge, belted	12.00
Drag scrapers	0.50	Car unloaders	1.00
Drag scrapers, two-wheel	2.00	Sharpening machine	18.00
Electric motors, 20 horsepower		Vises	0.50
Electric motors, 40 horsepower		Scows, 3 feet by 30 feet by 8 feet	5.00
Electric motors, 50 horsepower		Shears, McLane	0.50
		Tents, 12 by 14	2.00
Electric motors, 60 horsepower		Tents with flies, 12 by 14	3.00
		Tents, 10 by 10	1.50
Electric motors, 75 horsepower		Tents with flies, 10 by 10	2.00
		Taps and dies sets	0.50
Engine, vertical, 8	6.00	Typewriter	
Engines, horizontal, 25 horsepower	12.00	Bolt threading machine	0.50
		Leveling instrument	1.00
Engines, horizontal, 20 horsepower	10.00	Motor truck, 5-ton	
		Motor truck, 4-ton	
Engines, horizontal, 40 horsepower	15.00	Motor truck, 3-ton	
		Motor truck, 1½-ton	
Diving suits, complete	24.00	Concrete bucket, ¾-yard	2.00
Pump, pulsometer	10.00	Concrete bucket, 1-yard	2.00
Pump, diaphragm hand	5.00	Concrete bucket, 1½-yard	3.00
Pump, hand	2.00	Concrete bucket, 2-yard	3.00
Pump, gasoline 3-inch	8.00		

8. Derricks are to be complete with fittings, blocks, and a reasonable amount of guy wire and clips for guy derrick.

9. Hoisting engines are to be shipped complete with fittings and fall lines ready to connect with derrick. Fall lines to be replaced by us when worn out, if used with reasonable care.

10. All pumps to be complete with 16 feet of suction pipe or hose and foot valve and 10 feet of pipe for discharge.

Diaphragm pumps are to include the suction hose 16 feet long, and to be replaced by us when worn out.

Additional pipe or hose over 16 feet is to be charged to the job, and taken at the close of the job at its market value.

APPENDIX A

MATHEMATICS

Practical quantity surveying and estimating do not require a knowledge of the higher mathematics, but they do require a thorough understanding of the principles of mensuration, as well as of the conventional signs and symbols used by architects and engineers in designating the kinds of materials and other features on their plans.

While the surveying of some quantities involves only the counting of units, and some involves only the taking of linear measurements, by far the greater portion consists of finding areas and volumes. The following rules cover practically every problem of this sort that will be encountered.

Symbols Used in the Rules.

L = length.
B = breadth.
D = depth or thickness.
d = diameter.
r = radius.
n = number of sides.

Rule

1. Area of rectangular figure $= L \times B$.
2. Area of triangle $= \dfrac{L \times B}{2}$.
3. Area of circle $= d^2 \times 0.7854$ or $r^2 \times 3.1416$.
4. Area of ellipse = long diameter $\times$ short diameter $\times$ 0.7854.
5. Area of sphere $= d^2 \times 3.1416$.
6. Area of hemispherical dome $= d^2 \times 1.5708$.
7. Area of trapezoid $= B \times$ one-half sum of parallel sides.

8. Area of any regular polygon = length of one side $\times n$ $\times$ one-half perpendicular distance from side to center.
9. Area of ring = area of outer circle minus area of inner circle.
10. Area of any irregular polygon. Divide the figure into triangles, calculate, and add their areas.
11. Area of sides of a pyramid = perimeter at base $\times$ one-half slant height.

NOTE.—The slant height must be that at the middle of a side and not along the edge joining two sides.

12. Area of sides of frustrum of pyramid = the sum of top and bottom perimeters $\times$ one-half the slant height.
13. Area of convex surface of cone = $\dfrac{\text{area of base}}{\text{radius of base}} \times$ slant height or circumference of base $\times$ one-half the slant height.
14. Area of sides of frustrum of cone = (radius at top plus radius at bottom) $\times$ slant height $\times$ 3.1416.
15. Contents of rectangular solid = $L \times B \times D$.
16. Contents of cone = area of base $\times$ one-third height.
17. Contents of pyramid = area of base $\times$ one-third height.
18. Contents of frustrum of cone or pyramid = (area of base, plus area of top, plus 4 $\times$ area of plane midway between top and base) $\times$ one-sixth height.
19. Contents of sphere = $d^3 \times 0.5236$.
20. Contents of cylinder = area of end $\times L$.
21. Contents of prism = area of end $\times L$.
22. Length of circumference of circle = $d \times 3.1416$.
23. Length of circumference of ellipse = (square root of one-half of sum of squares of both diameters) $\times$ 3. 1416.

NOTE.—This is an approximate rule that is in general use and gives fairly accurate results. There is no simple rule in use that gives the exact length.

24. Length of hypotenuse of triangle = the square root of the sum of the squares of base and altitude.

25. Length of side of square inscribed in circle = $d \times 0.7071$.

NOTE.—The factor 3.1416 is sometimes represented by the Greek letter pi (π).

In each case where a portion of the rule is enclosed in parentheses, that portion should be worked before multiplying by the factor outside of the parenthesis.

Abbreviations.—The abbreviations recommended for use in expressing quantities when surveying quantities and in estimating are as follows:

in.	inches or inch.
ft.	feet or foot.
yd.	yards or yard.
lin. ft.	linear feet.
square	an area of 100 square feet.
sq.	square.
□	square.
sq. ft.	square feet.
□′	square feet.
sq. yd.	square yards.
□ yd.	square yards.
cu. ft.	cubic feet.
△′	cubic feet.
cu. yd.	cubic yards.
△ yd.	cubic yards.
M.	1,000.
FBM	feet board measure.
#	number, when written before numerals.
#	pounds, when written after numerals.
lb.	pound or pounds.
bbl.	barrel or barrels.
ϕ	round (usually, in reference to rods).

Linear dimensions are customarily expressed thus: 6′ 2″ equals 6 feet 2 inches.

Multipliers.—The following multipliers are to be used when calculating by means of key-operated machines:

Converting	Multiply by
Cubic inches to cubic feet	0.00058
Cubic feet to cubic yards	0.03704
Cubic feet to gallons	7.4805
Cubic feet to FBM	12.0
Cubic inches to gallons	0.0044
Cubic inches to FBM	0.007
Square inches to square feet	0.007
Square feet to square yards	0.1111
Cubic inches to pounds steel	0.284
Cubic inches to pounds iron	0.261
Cubic inches to pounds copper	0.319

Lumber: W in inches $\times$ B in inches $\times$ L in feet $\times$ 0.0833 = feet board measure.

Steel: W in inches $\times$ B in inches $\times$ L in feet $\times$ 3.40 = pounds.

APPENDIX B

RECOMMENDED READING

The estimator who would be thoroughly informed as to the many and various phases of his profession will do well, in addition to collecting all available experience data that come to him in the course of his own work, or which he can obtain through a reading of periodicals and by conversations with others in the same and allied lines of work, to obtain as many of the books listed below as possible and to familiarize himself with their contents.

ARTHUR, WILLIAM, "New Building Estimators' Handbook," U. P. C. Book Co., New York.

BARNES, FRANK E., "Estimating Building Costs," McGraw-Hill Book Company, Inc., New York.

CARVER, WILLIAM, "Brick, How to Build and Estimate," Common Brick Manufacturers' Association, Cleveland, Ohio.

CONNOR, FRANK L., "Labor Costs on Construction," Gillette Publishing Co., Chicago.

DINGMAN, CHAS. F., "Plan Reading and Quantity Surveying," McGraw-Hill Book Company., Inc., New York. "Accounting and Business Methods for Contractors," McGraw-Hill Book Company, Inc., New York. "Construction Job Management," McGraw-Hill Book Company, Inc., New York. "Building Estimators' Data Book," McGraw-Hill Book Company, Inc., New York.

GILLETTE, HALBERT P., "Handbook of Construction Cost," Gillette Publishing Co., Chicago. "Handbook of Construction Equipment," Gillette Publishing Co., Chicago. "Handbook of Cost Data," Gillette Publishing Co., Chicago. "Earthwork and Its Cost," Gillette Publishing Co., Chicago. "Rock Excavation, Methods and Cost," Gillette Publishing Co., Chicago.

Gillette and Dana, "Cost Keeping and Management Engineering," Gillette Publishing Co., Chicago.

Gillette and Hill, "Concrete Construction, Methods and Cost," Gillette Publishing Co., Chicago.

Hool and Johnson, "Handbook of Building Construction," McGraw-Hill Book Company, Inc., New York.

Knowles, Morris, "Industrial Housing," McGraw-Hill Book Company, Inc., New York.

Tamblyn, Gordon, "Building Labor Estimator," Gordon Tamblyn, Denver, Colorado.

Taylor and Thompson, "Concrete Costs," John Wiley & Sons, New York.

Trautwine, John C., "Civil Engineers' Pocket Book." John C. Trautwine, Philadelphia.

Underwood, G., "Estimating Construction Costs," McGraw-Hill Book Company, Inc., New York.

Walker, Frank R., "The Building Estimators Reference Book." Frank R. Walker, Chicago.

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